

# SCIENTIFIC AMERICAN

No. 539 SUPPLEMENT

Scientific American Supplement, Vol. XXI, No. 539.  
Scientific American, established 1845.

NEW YORK, MAY 1, 1886.

Scientific American Supplement, \$5 a year.  
Scientific American and Supplement, \$7 a year.

## THE NAUTICAL ARENA, OR AQUATIC THEATER.

A CONSIDERABLE sensation has been created in Paris by the opening, on the 12th of February last, of an aquatic theater. The spectacular entertainments in which water played an important part date back to the days of the Roman Emperors. The whole arena of the Colosseum at Rome being flooded, mimic sea-fights took place, in galleys carrying gladiators, who fought to the death. The Paris circus is remarkable for the beauty of the building and the ingenuity of the engineering details. The following description and engravings are from *Le Genie Civil, La Nature*, and the *Engineer*.

In the Rue St. Honoré is a building known as the Salle Valentino. This has been transformed—almost rebuilt, indeed—into a beautiful and luxurious circus, to which has been given the title *Arenes Nautiques*. It is intended to fill two distinct purposes—namely, to be used as a circus for equestrian, gymnastic, and aquatic performances during the winter, while during the summer it becomes a huge and splendid swimming bath. The engravings indicate the general arrangements adopted by the architects, MM. Sanffroy and Gridaine. We have omitted the vestibule, foyer, etc. The building was used until recently to exhibit the panorama of Reichshoffen, and the portion of it with which we are concerned is a great circular hall about 110 ft. in diameter. In the lower part of this is a circular tank, 79 ft. in diameter, with a gallery running round it. Over this gallery and the water are constructed tiers of seats, as shown in the section.

In the center is placed an hydraulic ram. To the top of this ram is fixed a huge iron saucer, 44 ft. in diameter. This saucer can be sunk below the level of the water, the surface of which is then available for

aquatic performances. When raised up, and the water run out of it, it supplies a firm floor for horses and men. All this seems very simple, but the details have required much consideration, and have been very ably carried out.

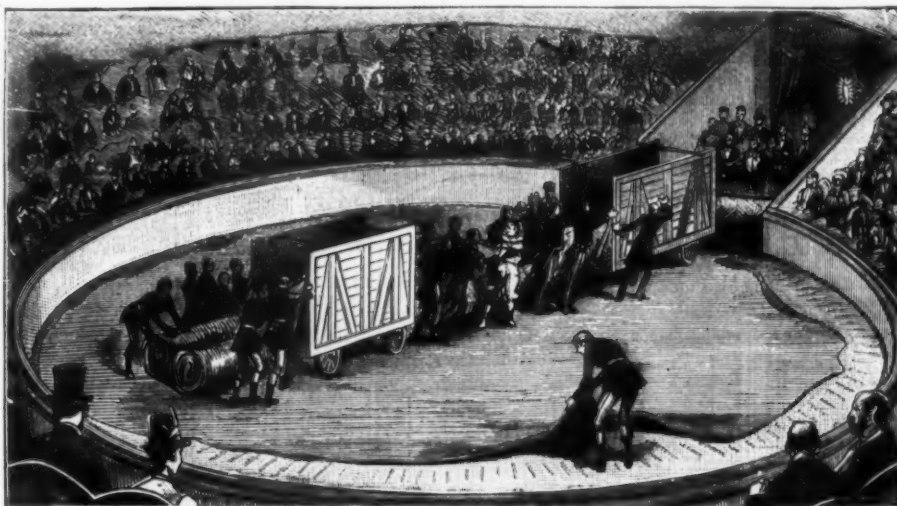
The building accommodates 3,000 spectators. There

is a circular lattice girder surrounding the space reserved for the saucer. This last had to be so constructed as to be quite rigid under the tread of numbers of horses and men, now concentrated in one place, now in another. It must be capable of disappearing during a performance, and without delay. It must during the bathing season be

maintained at such a height as to provide a shallow bath for those who cannot swim.

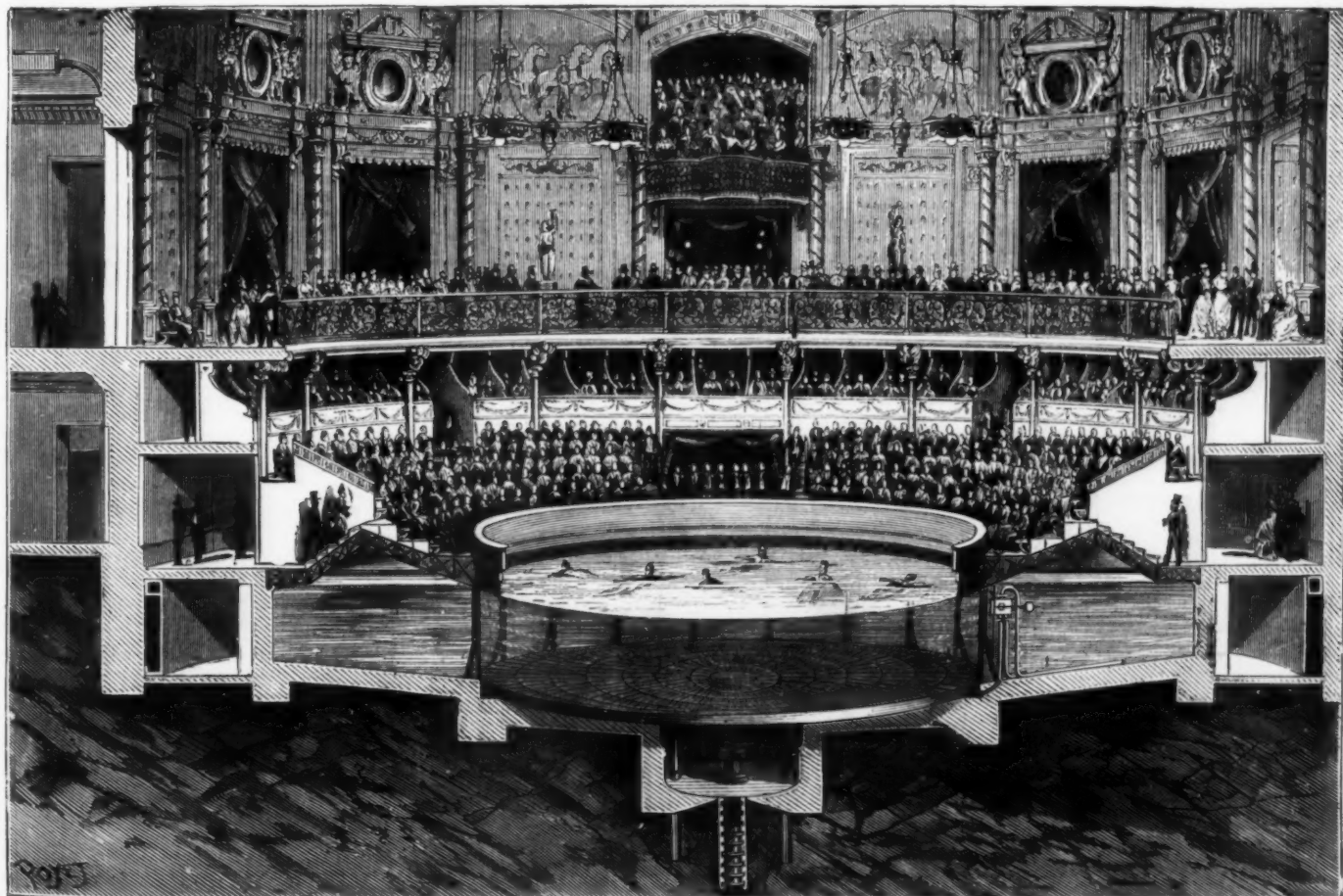
To comply with these conditions, the saucer is built up of twenty radial double-flanged girders, riveted outside to a continuous ring of plate iron. The girders are floored with stout planks to make the bottom of the saucer. The hub or boss from which the girders radiate is secured to the top of the hydraulic ram in the center, as shown in the enlarged section at the bottom. The rise of the ram is caused by the action of a four-barreled pump. The saucer is guided in its ascent and descent by planed slide bars round its outer rim. When it has attained a little more than its proper height, it is caused to rotate slightly on its vertical axis by an endless screw; by this means the ends of the radial girders are brought over twenty shoes, fixed to the twenty columns before mentioned as carrying the inner ends of the inclined girders which support the tiers of seats. Then by letting

a little of the water escape, the twenty girder ends settle themselves down firmly on the shoes. The inner portion of the saucer is at the same time carried by five stout columns ranged round the ram at a distance of 5 ft. from the center. Four of these are shown at A. A star-shaped cross-head or framework loosely embraces the ram at its upper part, where it is retained by a collar; and each ray of the star terminates in a collar, in which is loosely held the head of one of the columns. During the ascent of the ram the vertical columns are raised with it, by means of the star-shaped cross-heads; during its descent the columns enter pipes



THE AQUATIC THEATER.—PREPARING TO SINK THE STAGE.

are six tiers of fauteuils which are surmounted by a tier of boxes, above which, again, is a wide promenade gallery, connected with which is a cafe which serves as a foyer, and several bars. The orchestra is placed in a large balcony over the entrance to the stables, which last have stalls for twenty horses. In carrying out the internal arrangements, the contractors had serious difficulties to contend with. The whole of the fittings are removable, in order that the space may be cleared when the building is converted into a bath. The amphitheater of seats and boxes is carried on girders, is supported on twenty iron columns, united by a cir-



THE NEW AQUATIC THEATER, PARIS.

fixed in the ground, from which they are withdrawn as the saucer rises, until when it is at its greatest elevation they hang quite clear from the cross-head. A movement of rotation carries the columns over saddle plates fixed in the foundations, close beside the mouths of the pipes just referred to. Then, when, as we have said, a little water is allowed to escape, the saucer settles down, its outer edges resting on supports as described above, and the central cross-head on the five columns. To lower it, it is only necessary to raise it a little, turn it round a little on its axis, and suffer it to fall by allowing the water to escape from beneath the ram.

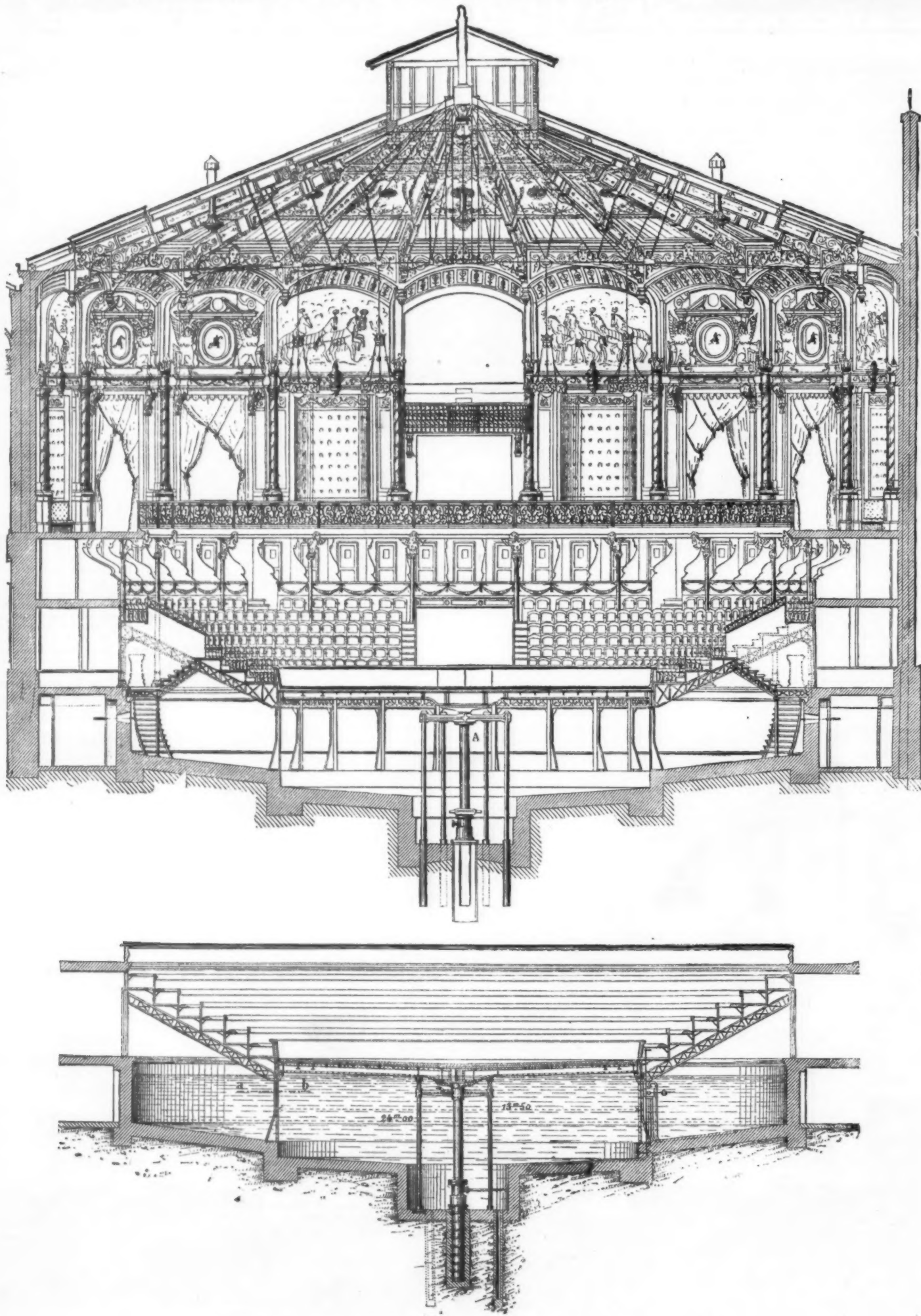
The weight of the whole mass moved is about 25 tons. India-rubber buffers and cushions are used to prevent noise and give the whole an even bearing on its supports.

When the saucer is used for equestrian performances its floor is covered with a mat of esparto, weighing about a ton, brought in on two iron carriages. This is said to be much better than sawdust. The rise and fall of the saucer is 10 ft., and the power required about three horses for five minutes.

To transform the hall into a swimming bath, all the seats and boxes are removed, and the saucer is dropped

to such a depth below the surface that the water in it is 3 ft. deep; all round it outside is the deep water for those who know how to swim.

The ventilation of a building standing over a lake, as this does, the water in which is always kept at a temperature of 77 deg. Fah., presents difficulties. The vapor rising from this, unless immediately drawn off, would render, by condensation, everything in the building damp. To prevent this a powerful fan, fixed in the cellars, draws the air from a turret in the roof, and after forcing it through a heating chamber delivers it into the hall under the seats at a tempera-



THE AQUATIC THEATER, RUE ST. HONORE, PARIS.

ture of about 86 deg. This would appear to be quite warm enough, but when a higher temperature is wanted the lantern on the top of the building is closed, and the air is then caused to circulate twice through the heating chamber.

All the arrangements for renewing the water are very ingenious, and well carried out. An abundance of water is obtained from a well, which supplies about 50 cubic meters, or 1,755 cubic feet, per hour. There are two distinct deliveries from the bath, one at the surface to draw off scum and froth, and the other at the bottom, which takes off the cooled water which has sunk, leaving the hotter fresh water on the top. The water is heated by the condensers of the electric light engines. M. Solinac is the engineer in charge of this department. Power is supplied by two Corliss 150

to follow, must be regarded as very surprising, for the strain is very great. The deflection shown in the engraving amounts to only  $\frac{1}{8}$  of the span, and could not have been very much greater than  $\frac{1}{8}$  in the span of which we have no view, since even that deflection requires a lengthening of the track of some  $\frac{3}{4}$  in. in a 30 ft. rail, which extension must, of course, concentrate itself at the joints and bend the spike over considerably to accomplish it.

The strain at the center (where it is least) of the "cables" of such a suspension bridge is given by the formula:

$$S = \frac{\text{clear span}}{\text{deflection} \times 8} \times \text{entire weight of clear span and load.}$$
 In so flat a "suspension bridge," the strain is

most only some 10,000 lb., or 35,000 lb. per joint. By assuming the deflection in the engraving to be twice as great as that assumed, or  $\frac{1}{4}$  (which it clearly is not), we might perhaps account for the phenomenon in the engraving, and the resulting necessary extension of 2'16 in. per rail length over the gap might be assumed to have been scattered backward through a number of joints beyond the gap. But, making the same assumption for the larger gap not shown, we still obtain a shearing strain of 37,500 lb. per spike, which is twice its probable ultimate strength.

We are, therefore, driven to the conclusion that something else besides the spike assisted to hold the rails together, and this can only have been the friction of the rail wedged in by the settlement between the base-plate and the "fore-lock," or the short block which caps the base of the rail and serves as a washer for the 1 in. U-bolt which goes under the rail and holds the joint and rails together. This friction might, no doubt, become very great indeed; but when all allowances are made, the record is, from every point of view, an extraordinary one, which seems all but impossible. As we know that it did occur, however, it is certainly an excellent illustration of what material will do at a pinch, and especially of what iron will do in a spike subjected to shearing strain.—*Railroad Gazette*.

#### THE SEVERN TUNNEL.

THE recent completion of the Mersey Tunnel, and its successful opening to the public traffic, call attention to a similar undertaking of older date and greater dimensions, which has been practically completed beneath the tidal estuary of the river Severn. But for the tremendous engineering difficulties encountered, and which have taken years to overcome, the honor of being first open to public traffic would have belonged to the Severn Tunnel, and not to the Mersey.

Compared with the Mersey at Liverpool, the river Severn at Port Skewett is of far greater width—no less than 2½ miles from shore to shore. At the point where the tunnel crosses under, the tidal rise is as much as 40 ft., and at the deepest point—the Shoots—the depth at high water is 100 ft. for a breadth on cross section of about 330 yds. The remainder of the estuary is comparatively shallow, being largely dry at low tide.

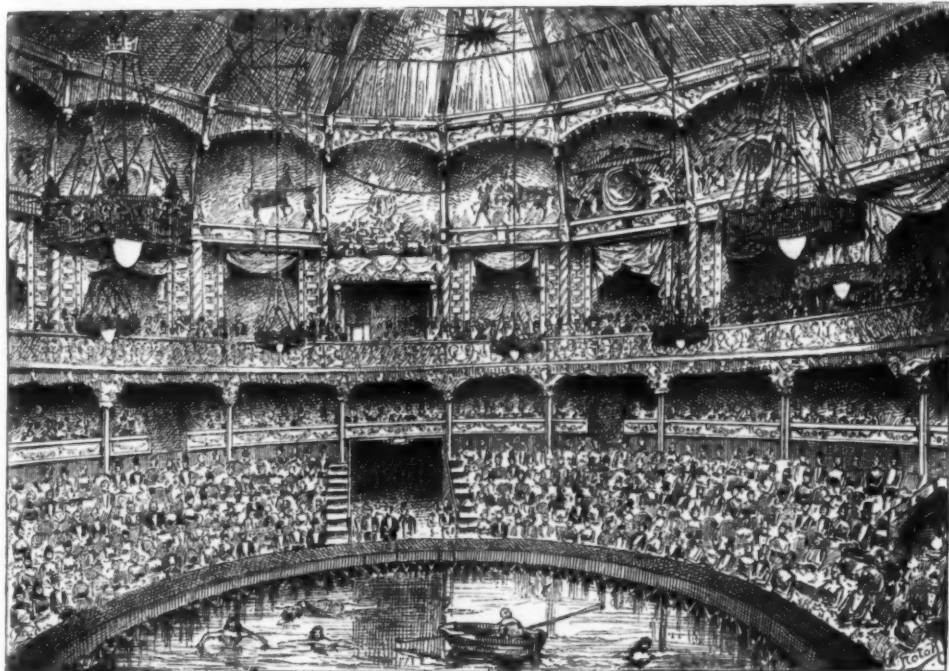
Thus it was necessary to give the lowest part of the tunnel something over 140 ft. below high tide level, and this point necessarily was below the Shoots. The total length of the actual tunnel is 7,664 yds., and it is approached at each end by deep cuttings 3,500 yards long through water-bearing strata, so that in the aggregate the drainage of about 6 miles 600 yards has to be provided for by pumping power.

As originally designed, the deepest point in the tunnel was to be approached by gradients of 1 in 100 from both sides, and the minimum thickness of material left over the tunnel crown was 30 ft. By the advice of Sir John Hawkshaw this was increased to 45 ft., by lowering the tunnel a further 15 ft., making the approaches 1 in 100 from England and 1 in 90 from the Welsh side as it is termed, but more strictly the Monmouthshire.

The tunnel passes chiefly through trias marls and sandstones, which are superposed in horizontal strata on older and highly inclined strata of coal measures, sandstones, and shales. For a short distance the crown of the tunnel is in gravel overlying the marl. Owing to a vertical fault in the strata the marls break off suddenly, and the tunnel passes to the coal measures of shales and sandstones, the latter of which in places is hard, though much fissured by the action of the above faulting, and here a good deal of water was found to penetrate in this portion of the tunnel. The coal measures continued for about 400 yds. on the Welsh shore, beyond which the tunnel is in a conglomerate of pebbles and bowlders, which was very troublesome from being so full of water and fissures. The coal measure shales and conglomerate have been largely used in the manufacture of bricks, many of which, of a very tough and strong nature, have been made on the ground by the contractor. They resemble Staffordshire blue bricks, of which also large quantities were used.

The tunnel works were begun in March, 1873—i. e., 13 years ago—by the Great Western Company, and after the original under-river driftway was completed within 130 yds., a large outburst of water, known as the big spring, burst into the headway driven on the Welsh side landward from Sudbrook shaft, and filled the works. This was in October of 1879, or 6½ years from commencement of works. The work was then let to a contractor, Mr. T. A. Walker, Sir John Hawkshaw acting as engineer-in-chief, with Mr. Richardson as engineer.

It was at this time that it was decided that the tun-



THE AQUATIC THEATER, PARIS.

horse power engines, driving two alternate-current Maquaire and two Edison dynamos. Steam is supplied by two Collet's water tube boilers. The lighting is effected by twelve Soleil lamps, six are lamps, ten Jablochhoff lamps, arranged in a crown in the center of the hall without globes, and 2,000 eight-candle Edison lamps, used for decorative purposes.

The whole interior of the building is luxuriously fitted up, and the entertainments provided are of the highest class. On the 12th of February the first part of the programme consisted of that usual in a circus. After the last act the heavy mat was removed, "and then," to quote the words of M. Henri Many, "we saw the immense saucer descend slowly, and immerse itself majestically in the waves. When the water began to rush across the flooring in clear view of the audience, the effect was irresistible, and the warmest applause saluted this new attraction, which permitted the audience to realize the progress of modern mechanical science."

#### THE STRENGTH OF SPIKES.

THE severe storm in Massachusetts in February last caused a great number of wash-outs on the railroads in the eastern part of the State, as we noted at the time, and among them a number on the Boston and Providence, from a photograph of one of which, at Eight-Mile River, near Hebronville, Mass., our engraving has been prepared. The gap in this case was 60 ft., and a close examination of the drawing will show where the joints are, about 15 ft. from each end. The track hung up there for two days, and many people walked over it, stepping from tie to tie.

There was, besides that illustrated, a still more remarkable wash-out between Mansfield and West Mansfield, of which, unfortunately, no photograph was taken. At this wash-out there was a gap of precisely the same character, but 150 ft. wide, or five rail lengths, over which the track hung suspended in precisely the way shown, and was still strong enough for people to walk over in the same way, which many did, as might have been expected, since there is no performance of that kind so foolhardy that men cannot be found to attempt it, if enough of them learn of the chance in time. We are indebted for the photograph and above information to Mr. A. A. Folsom, superintendent of the road.

The joints in use on that road are the Fisher bridge joints, and not angle-bars, so that there were no fish-bolts through the rails to hold them together. The rails were, however, notched for spikes, so that there were four spikes at each joint, or two spikes at each end of each rail, with a more or less imperfect bearing on the notch of the rail, and a much solidier bearing on the base-plate below (through a hole in which they are driven into the spike) to sustain the great longitudinal strain. As in the nature of things there must have been, among some 96 spikes at 24 joints for 5 rail-spans of double track, and 64 more for 16 joints in the wash-out illustrated, some whose bearings were more or less inefficient, there might reasonably have been cases where a single spike sustained practically the whole strain on one line of rails, although it hardly appears possible, from the computation below, that there were any which failed to act.

That under these circumstances no one of these spikes should have given way under the strain, and so dropped one track at least into the gap (for had one side given way, the other would have been almost sure

essentially the same throughout the "cable," only beginning to be considerably greater at the ends than in the middle when the deflection is very great. The load may be taken at some 200 lb. per yard of span per single rail, as thus:

	Per Yard.
Rail.....	70 lb.
Ties $1\frac{1}{2}$ per lin. yard of track, or $\frac{3}{4}$ per lin. yard of rail, weighing each say 150 lb., $\frac{3}{4}$ of which is.....	112 "
Joint, 40 lb., 1-10 to each yard of rail....	4 "
Dirt and live load.....	14 "
Total.....	200 "

This makes the total weight of and load on each rail:

For 60 ft. span, $200 \times 60 =$ .....	12,000 lb.
For 150 ft. span, $200 \times 150 =$ .....	30,000 lb.

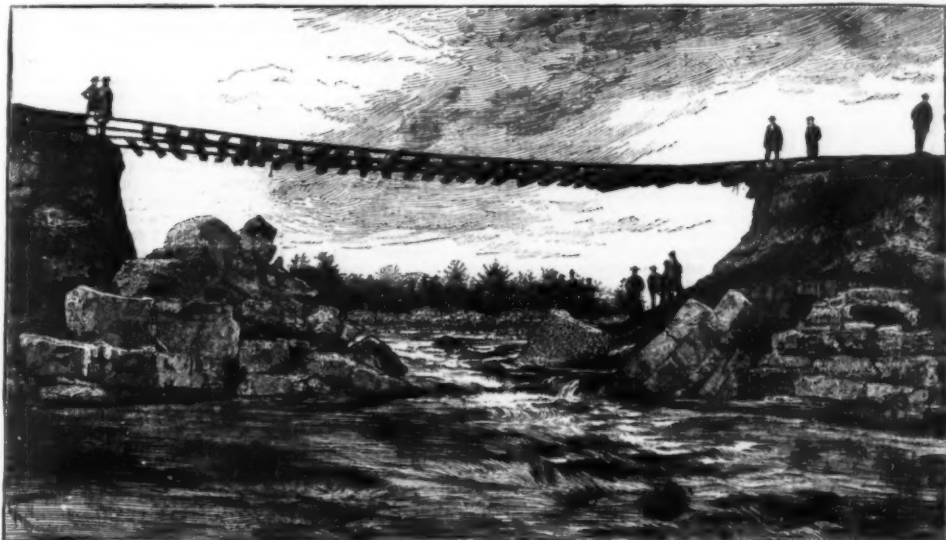
This makes the total tensile strain resisted by the shearing strength of the spike at each joint alike, assuming in each case a deflection of  $\frac{1}{8}$  of the span.

For the 60 ft. span (illustrated):

$$\frac{40}{8} = 5, \times 12,000 = 60,000 \text{ lb.}$$

For the 150 ft. span (not shown),  $5 \times 30,000 = 150,000$  lb.

This force was resisted, if such a force was resisted, by the shearing strength of the spike at most. But the ultimate shearing strength of wrought iron does not ordinarily exceed 60,000 lb. per square inch at most, and is usually less. A  $\frac{1}{4}$  in spike has 0.317 square inch of section, and can consequently resist at



THE STRENGTH OF SPIKES.

nel should be lowered 15 ft., and this was done by a parallel lowering of the whole English gradient and the steepening of the Welsh one. Below the tunnel heading a drainage driftway had been made below the main heading from the Sudbrook shaft to beneath the Shoots. After the alteration a second drainage drift of 5 ft. inside diameter, brick lined in three rings, was put through to the same point, and both of these are shown in our cross section.

Until the water influx of 1879 the amount of water encountered was comparatively moderate, and was easily dealt with by means of two 26 in. plunger pumps and an 18 in. and 15 in. bucket at Sudbrook. These pumps drained the under-river driftway and the land drift up to the 16th of October, 1879, when the big spring burst in at a point distant from the shaft 355 yds., and formed a little river of seven sq. ft. cross section, on a gradient of 1 in 100, 1 ft. depth. On the work now being let to Mr. Walker, the first thing attempted was to stop the water by fixing large oak shields over the openings to the shaft of the tunnel driftways, and by this means the pumps then at work lowered the water to below the shield level, or to a depth of only 30 ft. in the shaft.

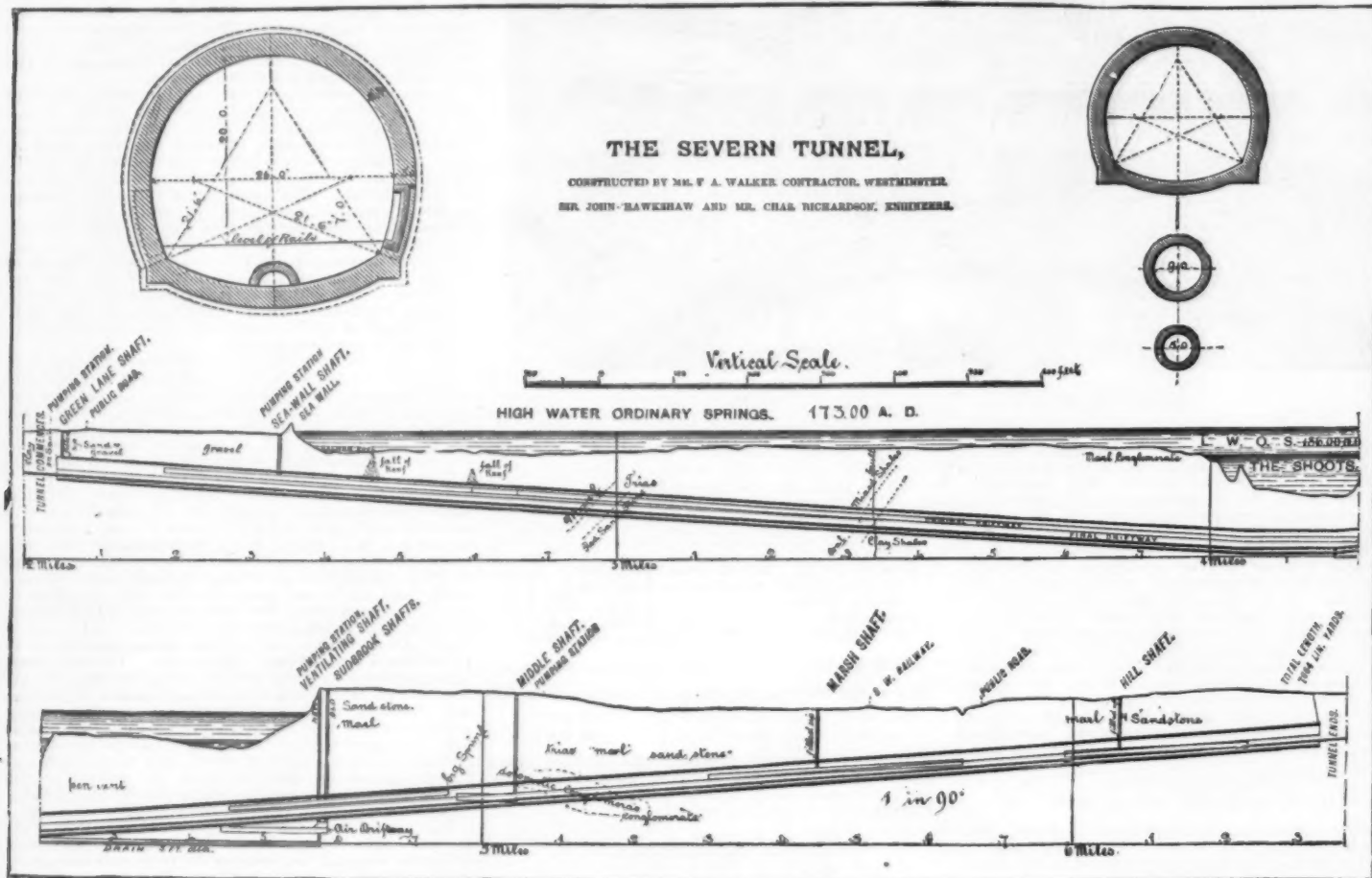
About 330 yards from the shaft and below the river in the driftway was a door shutting off this underwater driftway. It was desired to close this door. Divers could not reach it by means of their ordinary apparatus, as the incumbrance of air pipes was too great and dangerous. Diver Lambert, however, with a courage deserving of remembrance, and far superior to the brute courage of the soldier, heroically entered the drift, entirely cut off from all communication with the ground, and, literally taking his life in his hand, per-

explosive used was chiefly tonite, which was used to the extent of almost three tons weekly at times. The old bottom driftway became useless when the tunnel was lowered, as it was neither a top nor a bottom heading, and a new heading was driven, from which break-ups were made at intervals of two to five chains, and the complete tunnel bricked in at those points. Heavy timbering was used in the shales and gravels. In the good sandstone and conglomerate little or none was required. In all, shafts were sunk at eight localities to the number of fourteen, of which four were at Sudbrook. Of the fourteen, those at Marsh and Hill, Ableton lane, Green lane, and West face were filled up at the time of our visit early in February this year. The shafts were all brick lined except one at Ableton lane, one at the west face, and one at Sudbrook, which was tubbed in cast iron. There is now sinking a shaft of 20 ft. diameter at Sudbrook, which it is intended shall form a permanent pumping shaft. After the new pumps were erected at Sudbrook the pent-up water in the driftway was released on May 30, 1883, and the tunnel works have gone on uninterruptedly since then, though not without water outbursts. The spring supplied 6,000 gallons per minute, and this was easily dealt with by the pumps, and the old driftway toward the spring was cleared out. A new one was driven at invert level, which was fairly dry until it passed a point 97 yards from the old outburst, when water again entered suddenly, this time from below, filling up the works in 51 hours to within 95 ft. of high water. The flow was estimated at 27,000 gallons per minute, and the Sudbrook pumps had but 11,000 capacity. The doors in the driftways were closed while they had been provided for this contingency, this time also by Lam-

Sir John Hawkshaw, with whom is associated Mr. Charles Richardson, to whom and Mr. J. C. Hawkshaw we are indebted for many particulars of the undertaking. The contractor, Mr. T. A. Walker, is represented by Mr. Kenway, through whose courtesy we are indebted for the opportunity of inspecting the works generally, and Mr. A. O. Schenk is engineer to the contractor.

For particulars of the pumping plant we are largely indebted to the facilities offered by Mr. Peter Forbes, who has charge of the mechanical appliances for the contractor. We noted that in the larger pumps the valves are of the four-beat description, and are found to answer very well. The buckets of the pumps are water packed by means of a number of grooves about one-quarter inch deep, cut round the circumference of the bucket. They act by preventing the free flow of water past the bucket, each groove aiding in impeding the flow to such an extent that the result is an almost freedom from leakage and a perfectly free action, easy and frictionless. For the packing of all glands has been used throughout the packing of the Frictionless Engine Packing Co., of Manchester.

From our longitudinal section are plainly visible the various lengths of original headings which were driven from each shaft before the tunnel was designed to be lowered the 15 ft. in 1879. These lengths of heading are shown in the longitudinal section by two parallel thin lines, while the thin line next below, which diverges from the points 3 M, 4 F, and 4 M 2 F, is the top of the new bottom heading driven after the lowering was decided upon. The two lower thick lines show respectively the brickwork lining or invert and the rail level.



formed the dangerous feat in the Fleuss diving dress, remaining away 85 minutes, during which time none knew how he fared or whether he would ever return. He closed the door. Another door was afterward closed in a strong cross wall or dam, which was built across the land heading which had tapped the spring.

The wall was completed, the doorway closed, and the spring held back by this wall, which was three yards in thickness, after which the flow of water in the river Nodern and in the wells and springs all round, which had ceased to flow when the spring burst, again resumed. This being done, a new shaft was sunk at Sudbrook, and more pumping power put down, Nos. 5, 6, and 7 engines. In the mean time the tunnel works proceeded beneath the river, and at each extreme end, and by April, 1881, much of the tunnel had been bricked in, when on the 29th of that month there was an inrush of water through a hole 16 ft. x 10 ft. at the bottom of the Salmon pool, which had been caused by the flooding of the works, in 1879, bringing about cavities in the core above the driftway. This hole was stopped by throwing in clay puddle and covering with clay puddle in bags placed to form a large mound, which has since been leveled down and covered with concrete. This flooding only affected the English side, as the driftways were still not met beneath the river. A similar inrush would have occurred further beneath the river under the same pool, but the fall of roof was found in time. It extended 23 ft. in height and to within 20 ft. of the river bed. It was promptly shored up with timber and built up with brick in cement as soon as the tunnel beneath it was completed. The bulk of the water met with has been always in the land works on the Welsh side, the driest works being in the under-river sandstone and coal shales.

With the exception of part of the shales and gravels, blasting has been necessary throughout, the material being hard and tough, the shot holes being drilled by the Darlington rock drill and by a drill made by the Great-Western Company at their Swindon works. The

bert in the ordinary dress, assisted with the air pipes by two intermediate men, the distance being only 150 yards from the shaft.

When this had been effected, the pumps rapidly reduced the water, which had ceased to flow faster than about 10,000 gallons per minute, and a head-wall 88 yards from the shaft and 15 feet thick was built across the tunnel, fitted with an iron door and two 12 in. sluice valves. Pumps 5, 6, and 7, of 39 in., 35 in., and 31 in., at Sudbrook were now put down and set to work, the water being freed again in November, 1884, and since this the tunnel has been completed, all entrance to it from external headings closed and being entirely bricked in, the pumping was stopped and water allowed to accumulate outside. The brick lining of the tunnel varies from 27 in. to 36 in.

At the new shaft, which is now being excavated, it is intended that six engines, 70 in. diameter with 10 ft. stroke, shall be set to work three pumps 34 in. diameter with 9 ft. stroke and three pumps 35 in. diameter with 9 ft. stroke, with steam supplied by a range of 18 Lancashire boilers 28 ft. by 7 ft. diameter, at 50 lb. pressure. Steam at present is supplied by 10 Lancashire boilers 28 ft., and 50 ft. by 7 ft., and 12 Cornish boilers each 28 ft. by 5 ft. 9 in., the steam pressure being 50 lb. The present pumping plant will remain as auxiliary.

At the time of our visit, also, the foundations for a large 40 ft. fan were being prepared at Sudbrook for the ventilation of the tunnel, which has up till now been accomplished by a fan of 18 ft. diameter, driven by an engine, but which will of course be inadequate when the trains are regularly running through the tunnel.

This fan is being supplied by Messrs. Walker Bros., of Wigan. The pumping engines and Cornish boilers have been supplied by Messrs. Harvey & Co., of Hayle, Cornwall, who will also supply the new engines for the 20 ft. shaft.

The engineer-in-chief, as we have already said, is

The permanent way consists throughout of heavy longitudinal sleeper and bridge rails laid in ballast, with which the tunnel invert is filled. Within the ballast is a semicircular drain laid on the invert, which drains the ballast and conveys the water to the 5 ft. drain on the Welsh side. The whole length of the tunnel drains toward this 5 ft. drain from both ends, and is conveyed by this to the pumps at Sudbrook. Only a length of about 200 yards of the tunnel, below the Shoots, is horizontal.

Though the tunnel is virtually complete, and might any day be used for regular traffic, it has not been deemed advisable to do so until everything is complete.

The works at Sudbrook, therefore, still present an appearance of great activity. At the time of our visit the excavation of the new permanent shaft was proceeding rapidly, both downward from the surface and upward from its lower connection with the tunnel. When this shaft is complete, the big spring will communicate with it, and all openings with the tunnel will be closed permanently and no water allowed to enter it, being dealt with by the pumps on the outside of the tunnel, instead of, as now, on the inside. Hence, with the exception of slight drip or percolation, and such water as may enter from the tunnel entrances, it will be dry throughout, and very little pumping power will suffice to keep it so.

Referring to the cross sections of the tunnel, it will be observed that the upper portion is a semicircle of 13 ft. radius, below which the walls batter inward to a radius of 21 1/2 ft. to the invert, which also has a radius of 21 1/2 ft. The rail level is 7 ft. below the greatest diameter, and this again is 4 1/2 ft. above the crown of invert. As in the Mersey Tunnel (illustrated in our issue of March 5, 1886), there are recesses provided in the side walls, as shown, as places of safety and refuge from passing trains or as tool depositories for platelayers or other workmen. The relative positions of the 9 ft. driftway and the 5 ft. barrel drain at 4 miles 57 chains are shown in one of our cross sectional drawings.

In the excavation and bricking in of the tunnel, when the water was met with, it was led away by means of pipes which were built in and through the brickwork. These were allowed to flow for some time and some remained open at the time of our visit, but finally they will all be closed. The whole undertaking is one of great interest as an engineering work, and perhaps more than any recent work of great extent has depended for its success upon the outcome of mechanical engineering, for without pumping power nothing could have been done after the first great outburst of water.

LISTS OF THE VARIOUS SHAFTS.

	Diam.	Depth.
Ableton lane.....	18 ft. x 16 ft.....	55 ft.
Green lane.....	10 ft.....	74 ft.
Sea wall winding.....	18 ft.....	96 ft.
" pumping.....	15 ft.....	108 ft.
Sudbrook winding.....	18 ft.....	194 ft.
" pumping.....	15 ft. formerly winding	200 ft.
" .....	18 ft.....	204 ft.
" .....	12 ft.....	230 ft.
Middle winding.....	15 ft.....	150 ft.
" pumping.....	15 ft.....	155 ft.
Marsh winding and pumping.....	18 ft.....	105 ft.
Hill shaft winding and pumping.....	15 ft.....	86 ft.
West face winding.....	18 ft. x 10 ft.....	71 ft.
" pumping.....	15 ft.....	61 ft.

In the cross sectional views we show the tunnel form with the maximum thickness in dotted line. In the section showing air and driftways the relative positions of these in regard to the tunnel are shown for the point about 4 miles 57 chains in longitudinal section, a little east of Sudbrook shafts.—*Mechanical World.*

HYDRAULIC COLLISION BUFFER.

WITH the view of minimizing the effects of collisions both on land and water, a system of hydraulic buffers has been devised by Mr. W. F. Stanley, of London, which we illustrate. The invention is intended to be applied to ships already built as well as to be fitted in vessels in course of construction. Figs. 1, 2, and 3 of our engravings show the buffer adapted to a ship already built. Fig. 1 is an elevation, Fig. 2 a vertical section, and Fig. 3 a horizontal section of the buffer taken just above the boom, and which is thus described by Mr. Stanley: B, B', B', buffing spring arrangement shown as telescopic chambers; this chamber being otherwise filled with water and air. F F F, boom. G, hook to catch rocks. I R, India rubber buffer. Lamp shown above. C C C, shears to connect the collision buffer to a position inward of the head of the vessel; this part also acts as a spring. J J J J, joint by which the buffer is directed in any vertical position, or turned up when out of use, as shown in Fig. 2 by dotted lines U P. G R, guy ropes. R, raising rope. P, to pump to extend the buffer after a collision. E, to engines to stop or reverse them.

Fig. 4 shows a light collision buffer for new vessels, in which the joint, J', is placed at the head of the vessel to direct the boom. A second joint, J', permits the boom to turn up to make it portable. B' is a buffer guard, which acts only when the boom is turned up. W H is a warning whistle. The buffer spring, B', is of coiled steel. Fig. 5 is a portable collision buffer for large vessels, specially constructed for them. In this the boom is wholly telescopic. B' to withdraw within the vessel, the boom being extended either by a pump (pipe shown, P'), or by steam direct from the engines, or compressed air. E, pipe to stop or reverse engines. W, winch to elevate or depress the buffer. Details of this buffer are shown at Fig. 7, which is drawn to a quarter-inch scale. The whole of this buffer is movable upon a ball joint, the socket of which is constructed in the head of the vessel. This socket need fit the ball only upon the outer edges, which may have leather packings to make the joint waterproof at all positions. The joint will permit a horizontal movement of 15° on either side of the longitudinal axis of the vessel. It will also permit a depression from the horizontal plane of 30°, so as to bring the head of the buffer, when it is extended, to the plane of the keel. The buffer may be fixed in any required direction or angle in front by a rackwork arrangement. Pipes are shown entering the ball joint on each side of it, one leading to the pumps to extend or withdraw the buffer, and one to the engines to stop or reverse them by suitable apparatus when excess of hydraulic pressure is found in the buffer, such as would occur in a collision. It is not, however, necessary that this should be done by a second pipe; it may be done from pressure communicated through a junction with the pump pipe if thought desirable. It will be observed that the ball is chambered over certain areas at the ends of the pipes; this chamber is sufficient to accommodate the movement of direction of the buffer. An escape valve is shown under the back part of the buffer. From this a pipe will communicate with the open air along the lower part of the cylinder. An air valve at the highest point of the interior of the buffer cylinders will permit the filling of the buffer with water. The air valve will carry a float so as to close it when the water reaches it. Three India rubber bags filled with India rubber waste are placed in the fore part of the buffer to insure a soft, yielding contact at first upon any object with which the buffer may come in collision. Fig. 6 represents the same collision buffer adapted to landing stages, and for the sides of vessels to buff off tenders.

In describing the details of construction of his system, Mr. Stanley takes as an example the buffer shown at Figs. 5 and 7, and he says: "I will assume this buffer to be composed of four wrought iron tubes, each 20 feet long, bored and turned to leave a thickness of 1½ inches of metal to bear with safety an internal pressure of, say, one ton to the inch. The largest tube connected with the vessel will be closed at the inner ends. The smallest or interior tube will be closed at both ends. The outer ends of the three larger tubes will be provided with stuffing boxes, or piston ring fittings, or leather collars, as in a hydraulic press, so that the whole system will telescope together, forming at all extensions a stiff water tight compartment. The first or outer tube being fixed, the other tubes may be extended each 15 feet beyond its outer tube, leaving 5 feet of bearing. At this position each tube must be stopped

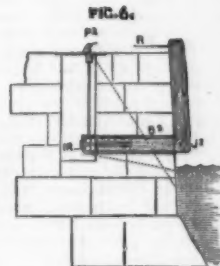
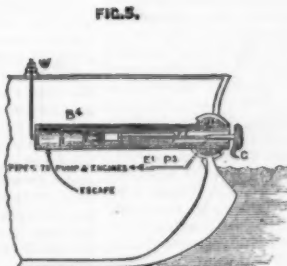
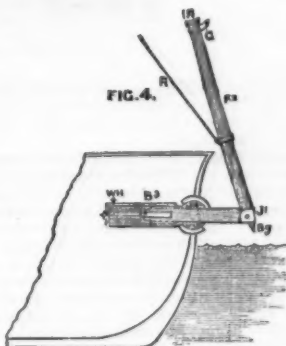
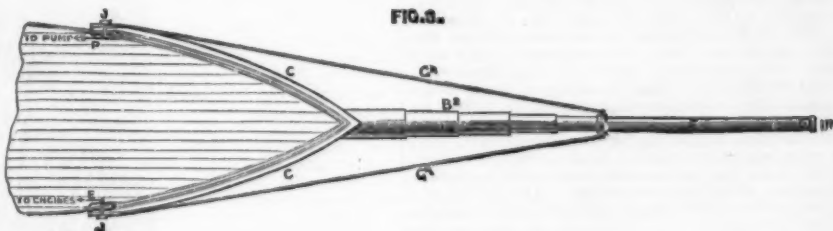
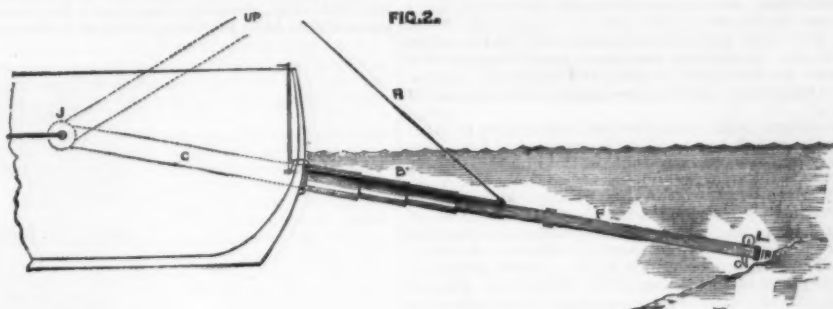
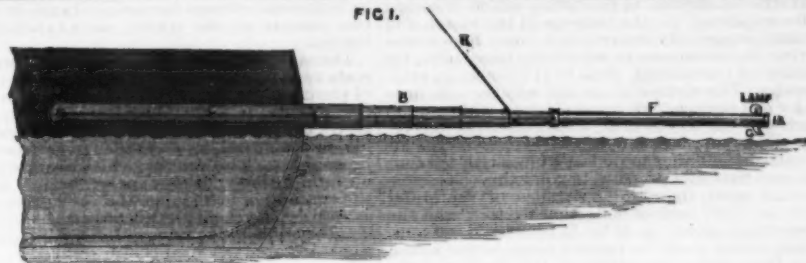
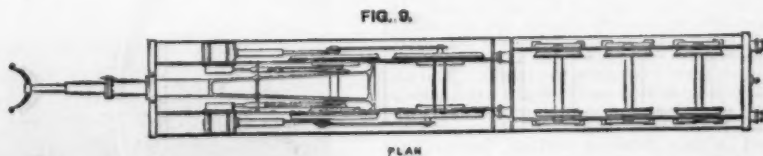
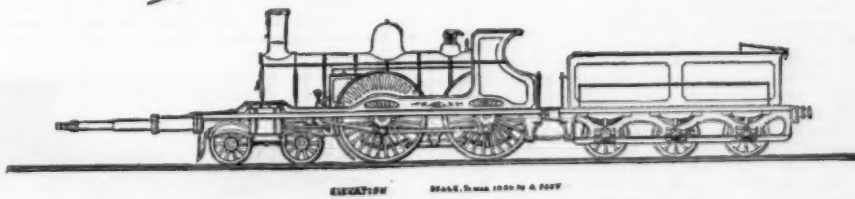
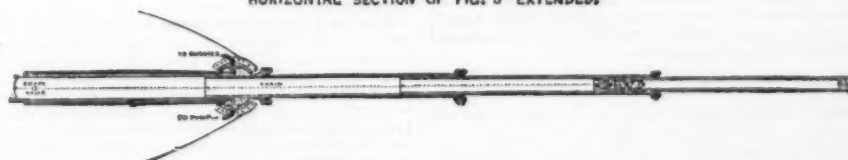


FIG. 7. HORIZONTAL SECTION OF FIG. 5 EXTENDED.



HYDRAULIC COLLISION BUFFER.

by a chain from the inside or otherwise. Upon these conditions the head of the buffer, by the extension of the three tubes, may be projected altogether 45 feet in front of the vessel, and form in this position a stiff boom. Now, assuming the hydraulic system is selected to work this buffer, it will require a pump from the en-

gines, an elastic chamber (air bag, or one filled with India rubber waste, I propose), and a spring valve, which will open with a pressure of 1 ton to the inch, to let the water escape from the interior when the pressure exceeds this. Such arrangements being complete, the pump will be applied to extend the buffer in times

of danger to the full range of 45 feet. I have not yet discussed the diameters of the tubes, which of course would be regulated to the tonnage of the vessel, and the amount of security desired, but I may take a case to discover the resistance in which the inner tube, for convenience of calculation, shall be 11.3 inches in exterior diameter. The surface of the end will then be, near enough for our purpose, 100 square inches, which, upon a pressure of 1 ton to the inch, would offer 100 tons resistance. Now, suppose the elastic system of the air bag permitted the buffer to deflect 1 inch with 100 tons pressure, and that at a pressure beyond this the escape valve would open, then the resistance of the buffer would be for every inch of deflection 100 tons, and the entire resistance would be 45 by 12 by 100=54,000 tons, before the buffer could be pressed home to the vessel, deducted from the momentum of the vessel and the system of water which moves with it. Now, if the collision were upon a solid rock or a large iceberg, the resistance would be entirely within the space of 45 feet; but if the buffer were in collision with another vessel, in the time the buffer would deflect 45 feet the other vessel would be moving, and space would be given for the water to form also an effective resistance, assuming the engines stopped as proposed at the instant of collision."

Mr. Stanley's collision buffer for locomotives is illustrated in Figs. 8, 9, and 10 of our engravings. And here he simply proposes to introduce on the line the principle so successfully carried out in practice by Mr. A. A. Langley at railway stations in his hydraulic buffer stop, which was described and illustrated in *Iron* of February 19th last. Mr. Stanley's buffer is intended to lessen the effects of accidental collision of trains under all circumstances, and is to be placed centrally in the fore-part of the locomotive. This form will be suitable for the class of locomotives to which it is shown attached in the engravings. The same principle of buffer may be applied to other forms of locomotive, but duplicated, so as to take the position of ordinary buffers. The buffer is shown extended in all the figures of the engravings, but it is so arranged that it may be entirely withdrawn, so as to form no impediment to the general portability or the handling of the locomotive, as upon a turntable, or when placed in a shed, or on a siding with sharp curves. Where no space can be provided for this buffer under the locomotive, Mr. Stanley proposes to construct it so as to turn up. Fig. 8 shows the form the buffer would take when in use for the protection of a train in motion. At the end of a journey it can be withdrawn by causing the pump to work in the reverse direction through an inlet at the opposite end of the barrel of the pump, and a pipe connected with the buffer just above the outlet valve. The method which Mr. Stanley anticipates would answer best would be to work the buffer entirely with cold water. The spring valve should then open with about 1,300 pounds to the inch of pressure. The end of the piston would have about 60 square inches of surface. The locomotive coming in collision at a velocity of, say, twenty miles an hour should suffer a continuous resistance after contact upon the buffer of about 30 tons per inch of its direct trajectory during the time that the buffer was telescoping in, that is, after the spaces of smaller elastic resistance first taken up by the head-spring and the air bag. Thus, if the buffer at full extension was 7 feet 3 inches, the total resistance after allowing 3 inches for the ordinary buffing, would be about 7 feet by 12 inches by 30 tons = 2,520 tons to close the entire 7 remaining feet. This Mr. Stanley is of opinion would be in most cases sufficient to prevent a collision doing serious harm either to the locomotive or the carriages. Mr. Stanley further proposes that pressure upon the interior of the buffers, such as would instantly occur in collision, should through suitable apparatus instantly cut off the steam and put on the automatic brakes where they are used. The whole scheme is certainly ingenious, but it is questionable whether Mr. Stanley will succeed in getting naval architects and sailors on the one hand, and locomotive superintendents and engine drivers on the other, to regard his invention with favor.—*Iron*.

#### PROGRESS IN RACK RAILWAYS.

The rack railway dates back, so to speak, to the very origin of railways, since the engine built in 1811 by Blenkinsop, director of the Middleton coal mines, was provided with a cog-wheel that geared with a rack. But this arrangement was afterward entirely abandoned, owing to the success of engines operating by simple adhesion. Although this idea has been the object of numerous patents, it was never practically carried out before the construction of the railroad from Indianapolis to Madison, which was established after this type by Mr. Cathcart, in 1847. This line, the traffic of which was comparatively light, was operated in this manner up to 1868, the epoch at which Mr. Sylvester Marsh finished the construction of the celebrated Mt. Washington line, which had been begun in 1866. This line (see Fig. 1) presents a peculiarly steep gradient, and one much stronger than that of the Righi road. It was operated at first by the Fell system, but the slight success of the latter afterward decided the managers to adopt a locomotive that made the ascent through the aid of a rack placed between the tracks. The arrangement is the same as that on the Righi road, which we have already described and so shall not dwell upon. The locomotive has a boiler that is movable upon two trunnions, and always remains vertical, despite the variations in profile. In order to prevent derailment, the engine is provided with friction rollers, which are suspended from the frame and remain in contact with the rack.

In Europe, the study of rack railways has been pursued by Mr. Riggensbach, who has attached his name to this special type, and whose most curious applications we have already examined. Let us, for example, recall (aside from the two lines running to Righi from Arth on Lake Zurich and from Witznau on Lake Quatre Cantons) the Giessbach cable road and the Rorschach-Heiden mixed line, which is an ordinary road prolonged by a rack. We may also cite the Kahlenberg line, in Austria, that of Schwabenberg, the industrial road of Ostermündingen connected with the line from Berne to Thun, and the Wasserauffingen, Rutli, Oberlahnstein, and other lines.

In these different applications the roads are all constructed after one uniform pattern—that of the Righi line. This arrangement, however, presents certain

drawbacks that had to be remedied in order to secure an industrial success for rack railways in current practice, outside of the special cases to which it had been limited.

The rack, which is established in the form of a ladder, costs very much to construct, by reason of the necessity of piercing the uprights and cutting out and riveting the rounds; and, besides, it necessarily always preserves the same dimensions, and it is therefore impossible to proportion its resistance to the stresses that it is to support. The rounds, which are always laid at the uniform distance of four inches, are too wide apart for the running of fast trains, and perceptible shocks occur as soon as the velocity reaches five miles an hour. Finally it is very difficult to remove foreign objects that chance to get inserted between the uprights.

On another hand, the locomotive itself must have a cog-wheel of large diameter in order to gear with the rounds of the rack, which latter engages with intermediate steel gearings that must be fixed with great accuracy so as to prevent jolting and breakage.

and small roads, tramways, and cable roads. Those for large roads are formed of three parallel bars forming as many distinct racks, the toothing of each extending beyond that of the other. These three racks are held by peculiar chairs attached to the ties by screws. They are held at the extremities by fish-plates, which secure an invariable pitch between the two successive racks. Finally, care is taken not to allow the extremity of three racks to rest on the same chair.

Upon secondary lines but two racks are used, and these are laid in the same way.

For tramways Mr. Abt has arranged a type of rack that may be laid upon the very roadbed without producing any depression or projection capable of interfering with the running of other vehicles. To this effect, the rack consists of a simple bar of steel placed on the surface of the road, and containing equidistant apertures with which the teeth of the locomotive's cog-wheel engage. This bar is fixed by small angle irons upon the vertical arms of a U-shaped iron, or by large angle irons which are themselves fixed upon the

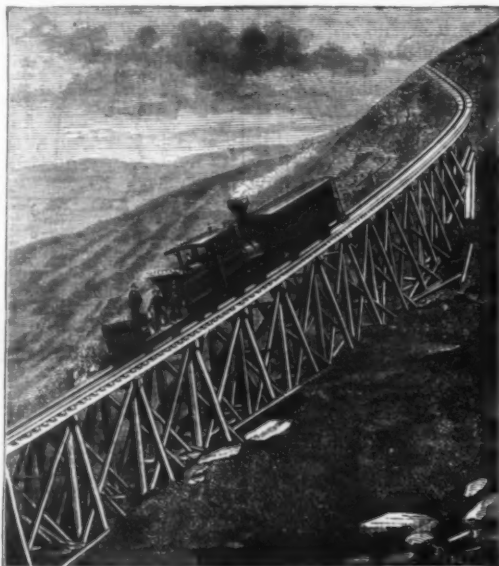


FIG. 1.—THE MT. WASHINGTON RAILWAY.

This arrangement, which is very costly, is accompanied, in addition, with considerable friction, which absorbs a large portion of the motive power, and leads to a rapid wear of these parts.

Finally, mixed locomotives designed for operating at the same time as simple adhesive engines upon smooth tracks are run under very defective conditions. The driving wheels must, through adhesion, make one entire revolution at the same time that the toothed wheel does, and the two kinds of wheels must therefore have precisely the same diameter. Such a condition evidently cannot long remain in force, since the driving wheels wear very quickly, and some have a diameter less than that required by the revolution of the toothed wheel. They are consequently continually sliding, and this again hastens the wear and increases the jolting while running.

All these inconveniences are done away with in the rack system of Mr. Abt, of Zurich, which we shall describe from a study published in the *Genie Civil* by Mr. Abadie.

The rack here (Fig. 2) consists of toothed bars which are kept parallel by the action of the supports that connect them with the ties. They are laid vertically, with their teeth alternating. The bars are of steel, and the number and thickness of them may vary within somewhat wide limits, thus allowing of their always being proportioned to the tractive stress developed by the locomotive. However, the usual limit is four types, which appear to answer all the needs of practice, and which are generally designated by the style of road to which they are applied. We thus have racks for large

ties. The rack thus formed constitutes a sort of hollow girder, which is easily cleaned by simply injecting a current of water, since these roads are always inclined. Upon roads of some importance a double row of apertures is usually arranged, so as to form a double rack for the hauling of trains.

Mr. Abt's style of rack presents very marked advantages as regards the working of a road, since it secures a continuous contact with the teeth of the engine's cog-wheel, several of which are always simultaneously in gear with it. Under such circumstances there is no jolting, and this permits of the running speed being increased up to twelve and even fifteen miles per hour. As it is especially upon mixed roads that racks find their truly industrial application, the operating of such railways must be done with mixed locomotives, running through simple adhesion upon the smooth track, and gearing with the rack through a cog-wheel. Since it is important to secure the entrance of the engine on the rack portions without there being any need of stopping, Mr. Abt has devised a special mechanism to effect this. It consists of a rack bar movable around a horizontal axis, and the free extremity of which rests upon spiral springs bearing against the tie. This device had already been applied in the old type of rack, but in the new one the impulsion is effected with so much the more facility in that the mechanism of the cog-wheels is independent of that of the driving-wheels, and the teeth of the movable part progressively gear without the occurrence of any sliding as a result of a difference in diameter between the two types of driving-wheels.

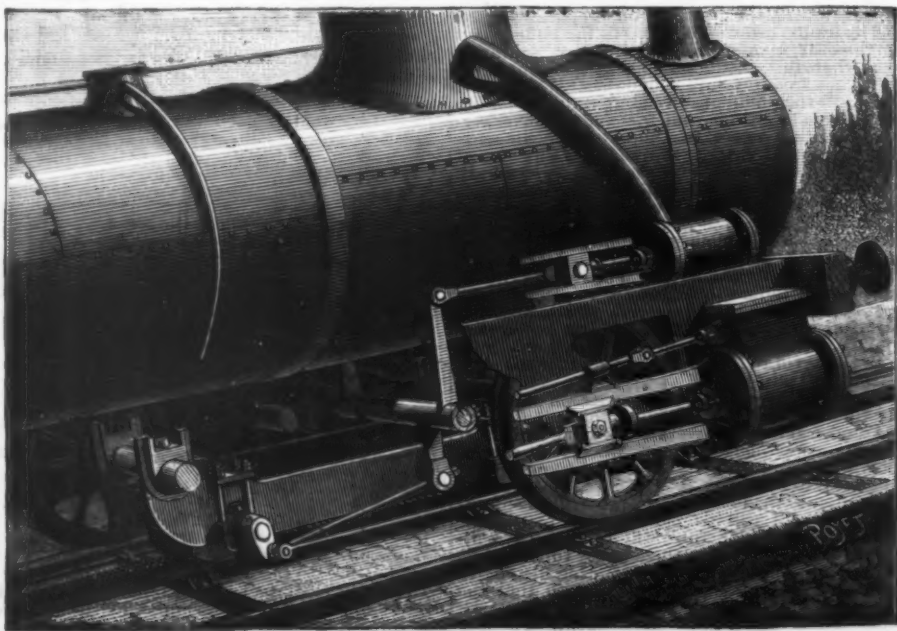


FIG. 2.—ABT'S RACK LOCOMOTIVE.

The engine, which is shown in Fig. 2, has a unique boiler, and possesses two motive mechanisms, one of which actuates the driving-wheels, and the other the cog-wheels. The driving-wheels, which are six in number, are coupled, and are actuated by the mechanism of the two external cylinders. The cog-wheels, on the contrary, are connected with the pistons of the two internal cylinders under the smoke box. Each of the two pairs of cylinders is provided with a special distribution that secures a perfect independence of the two mechanisms; still, that of the cog-wheels cannot operate independently of the driving-wheels.

The cog-wheels are mounted upon peculiar axles, and consist of disks equal in number to that of the racks. Their toothing corresponds to that of the latter, so that it may engage continuously therewith. Besides, they are not keyed firmly to the axle, but are allowed a certain freedom of oscillation through the interposition of an elastic substance around the holding bolts, thus permitting them to always engage with accuracy despite the inevitable variations that the teeth of the rack always present. This characteristic arrangement, which is most ingenious, makes the engine run with an easy motion, without jolts, and secures a perfect distribution of the tractive force. In order to stop the train in case of accident, the engine is provided with friction and air brakes of great power, some of which act upon the axles of the cog-wheels, and others upon those of the driving-wheels. The simultaneous action of these different brakes suffices to stop the motion of the engine and bring the train to a standstill by affixing it to the rack.

Mr. Abt's locomotive for the Hartz railway weighs forty-two tons, and is capable of developing a tractive power of twelve tons, on the action of the two mechanisms being combined. It is capable of running at a speed of seven miles an hour, and of hauling a 240 ton train up an incline of half an inch to the foot.

These new and interesting arrangements, as may be seen, appear then to be called upon to give a new impetus to rack lines, which latter are thus to become really practical from an industrial standpoint. The trial that has been made of them, moreover (especially on the great Hartz line, from Blankenburg to Tanne), under various conditions as regards gradients, has given the most satisfactory results.—*La Nature*.

#### ECONOMICAL RAILWAYS.

At a recent meeting of the Institution of Civil Engineers, London, the first paper read was "On the Economical Construction and Operation of Railways in Countries where Small Returns are expected, as exemplified by American Practice," by Mr. Robert Gordon, M. Inst. C. E.

In a paper read before the American Society of Civil Engineers, Mr. Edward Bates Dorsey stated that while the 18,681 miles of railway in the United Kingdom in 1883 had cost over 40,000*l.* per mile, at the same date 110,414 miles had been completed in the United States at a cost averaging 12,400*l.* per mile, the cost of operation for the former being about 2,000*l.* per mile, while for the latter it was 890*l.* during 1883. The ton-mileages of the two systems were 9,589,786,848 and 44,064,923,445; and passenger mileages 5,494,801,496 and 8,817,684,503 respectively. The average rates charged were 0.01*d.* and 0.0012*d.* per ton-mile and 0.0115*d.* and 0.0121*d.* per passenger-mile respectively.

On the Baltimore and Ohio Railroad, which was the most extreme type among the great trunk lines of the American method of construction, with high summit level, steep gradients, and sharp curves, the author found that the extra cost of working due to these difficulties was only 8 per cent. In deducing a comparison, it should be remembered that the greater portion of the English lines had double tracks, while the larger part of the American mileage was single. Again, while most of the land belonging to the American companies cost them nothing, it was computed that in England fancy prices for land had added from 4,000*l.* to 5,000*l.* to the average cost of the railways per mile. On the other hand, inflation and watering of stock were computed to have added from 2,000*l.* to 3,000*l.* per mile to the cost of American roads.

The actual charges for construction were probably 35,000*l.* per mile in the United Kingdom and 10,000*l.* in the United States. Hence, railway construction must be carried out more economically in America than in England and Europe generally. Mr. Dorsey claimed that a railway could be constructed on the American system at from one-half to one-fourth the cost of the English system, and be in working order in from one-half to one-fourth the time.

The essential differences between American and English practice originated in the universal use by the former of the bogie truck, with short, rigid wheel-base and flexible connections between the wheels and bodies for all rolling stock, as compared with the general use of longer wheel-base and more rigid connections by the latter.

The working of the railway system in North America had been undergoing a great revolution within the last few years, owing, first, to the introduction of steel rails and rigid fishplates; and, secondly, to the very severe competition between the leading trunk lines for the east and west heavy freight traffic. Bridges had been strengthened or replaced; loads of 40,000 lb. to 50,000 lb. were carried on the old cars, which used to take only 20,000 lb.; newer and stronger designs were being produced, and while every effort was being made to keep down the dead weight of cars to below 20,000 lb., paying loads of 60,000 lb. and 70,000 lb., and even more were regularly given to them.

There was a strong tendency in America, in industrial processes, to adopt types capable of automatic reproduction in identical forms. Several points of the railway system came within the scope of this tendency. Probably by the end of 1884 nearly all the broad gauge lines in the United States would be brought to the standard gauge of 4 ft. 8½ in. For some years the Louisville and Nashville Railroad (2,400 miles long) had been prepared, so that, by turning down the blank collars in the axles, all the rolling stock would be reduced from the 5 ft. gauge at a short notice. It was the practice to run cars belonging to one line over almost every other line, the owners often not regaining possession of their stock for months or years. The Master Car-Builders' Association and kindred societies were trying to introduce uniformity of shape and size in the tops of the rails and in the treads and flanges of

the wheels; and a standard freight-car truck was also the object of much solicitude. Hitherto the only standard article universally accepted was the freight-car axle. There had been a tendency of late years to resort to steel-tired wheels, the life of some of which averaged over 300,000 miles, and which in the end proved more economical than the cheaper cast-iron wheels.

Under the guidance of Mr. M. N. Kerney, efforts had been made for some years to secure the establishment of a standard freight-car truck, and with the active concurrence of many experienced builders, there was a prospect of this being adopted. The proposed truck had a wheel-base of 5 ft. Its framework was of the so-called diamond type, the name being taken from the shape of the sides. The car body was loosely connected to it by a center pin held vertically in the middle of the bolster, on which it could turn a complete circle. The bolster rested on springs, and might be either rigid laterally or have a swing motion. In passenger-car trucks the bolster and spring plate were carried on side-equalizing bars, which rested on the axle-boxes, and further lessened shocks from the road-bed by additional springs. In principle all the trucks, whether for cars or engines, were the same, and aimed at giving the greatest amount of ease of motion compatible with safety.

This flexibility, with the short, rigid wheel-base of 5 ft., was characteristic of the American freight car, as compared with the absence of flexibility and long, rigid wheel-base of 8 ft. or 9 ft. in an English goods wagon, and these qualities enabled the former to work well on rough roads, with sharp curves, that the latter could not run upon. Designs for standard trucks for the Pennsylvania Railroad, and for the Union Pacific narrow gauge line, were described. The truck for the former line was for cars to carry 60,000 lb. It was built entirely of iron.

The Union Pacific narrow gauge truck was to carry cars with 40,000 lb. burden, or the same as the standard gauge car trucks. Its wheel base was 4½ ft., or 6 in. less than that of the standard truck. With the exception of the bolster and spring plate, which were of wood, all the parts of the standard truck were of iron; and it would be possible to substitute iron, as in the Pennsylvania truck, for the wood. In this case every separate part might be reproduced with accuracy, and if a standard of strength and quality of metal could be secured, there would be a complete interchangeability of the different items, and a consequent reduction of cost, both in the material and in the labor of putting the parts together. In the author's opinion this standard freight-car truck, having established itself by the survival of the fittest, was likely to become the initial point and unit of reference for ordinary railway work in the future. As a rule, only two trucks were used to each car, but latterly a third truck had been introduced under the center of the car body.

The hopper gondola car of the Pennsylvania Railroad was designed to carry 60,000 lb., and weighed only 19,800 lb. By dispensing with the hopper it becomes a plain gondola car, and if the sides were removed it was a common flat car.

The author did not consider that any claim could be made for exceptional economy in the conveyance of passengers in America, nor was the service more efficient than in England.

The practice was becoming general, and opinion was universal, in favor of automatic brakes being applied to freight cars, preference being given to separate application on every wheel. The Westinghouse air brake was extensively used, but its expense was against its universal adoption.

In American locomotives, the solid bar-frame was retained, generally forged throughout, and it was rigidly connected to the boiler, forming with this a complete truss. Outside cylinders were universal in American practice, with steel fireboxes, cast-iron wheels, and equalizing bars for all the wheels. In engines with long wheel-base alternate sets of wheels had broad treads without flanges, and were called blanks. Minor differences from English practice, such as the cow-catcher, the spark arrester on the smoke stack, the enormous lantern, the bell, and the cab for the attendants, with a more ornate general appearance, were to be observed in American locomotives.

Of late years in the best English practice, the principle of flexible wheel-base in locomotives had been adopted so far that the American bogie, or the Adams bogie, or some equivalent like Mr. Webb's radial axle-boxes, were in general use, while on some lines equalizing bars were also used. Sketches in outline were given, with a few data of late practice in American locomotives, showing the principal types adopted.

In designing new roads in America with the utmost attention to economy, the best practice tended to make the bridgework strong enough to carry a train of locomotives such as were to be generally used on the roads. Following this out to its legitimate conclusion, the freight cars should be loaded up to their utmost capacity, to secure the greatest proportion of paying load to dead load, within the limit of equal weight per lineal foot of car for weight per lineal foot of locomotive. This was already being approximated to on the best lines using the heaviest engines.

On the new road now in course of construction in South Pennsylvania, the bridges have been designed to carry a train with two coupled "Consolidation" engines, each weighing 171,000 lb., with 24,000 lb. on the drivers or one "Decapod" of 195,000 lb. with the tender. The iron bridgework of the Canadian Pacific Railway was designed to carry a train of locomotives, of "Consolidation" type, with 21,360 lb. on each driver, and a total weight with tender of 166,820 lb. on a length of 56½ ft., or nearly 3,000 lb. per lineal foot. On the Pennsylvania Railroad, trains averaging one hundred loaded cars were taken over the line. On steep grades they were conveyed by two "Consolidation" headers and one pusher. Probably they would take some 3,000 tons of paying load per trip. It was in this direction of enormous paying train-loads, carried on a minimum of dead weight, that economy was sought by the trunk lines in the heavy east and west traffic.

Up to the present time the 82 lb. steel rail was the heaviest used in America. The cross-ties or sleepers were invariably closer together in American than in English practice. The rails were mostly 30 ft. long, and at least sixteen cross-ties of 8 ft. to 9 ft. in length, 8 in. in width, and 6 in. to 7 in. in depth, were general-

ly laid to each length on the standard gauge. The flat foot of the rail was from 4 in. to 4½ in. broad, so that with the larger number of sleepers the bearing surface was much greater on the wood than in English practice; and this again had a broader spread on the earth, securing more elasticity to the roadway. There was a decided set of opinion among the best American engineers against light rails, either for narrow gauge or so-called light railways. Economy was to be sought for elsewhere than in either rolling stock or permanent way, meaning by this the rails and sleepers. Economy of construction of American railways consisted in the small outlay in first cost of grading, alignment, and heavy works, and in the gradual adaptation of the roads to the traffic requirements.

The United States was divided physically into two immense plateaus, of equal extent, by the 99 deg. meridian, that to the east rising from the sea level to an average of 1,000 ft., while the western rose to a mean height of over 5,000 ft. above the sea. Both to the north and to the south the ranges descended to where they were crossed by the great transcontinental or Pacific roads. The descent from the western plateau to the eastern was generally easy, though considerable irregularities were met in the foothills where branches of the great Granger or Northwestern roads penetrated.

The Appalachian range was crossed by the Baltimore and Ohio Railroad at a summit elevation of 2,706 ft., to which it ascended by continuous grades of 1 in 45, over 11 miles on the one side and nearly 17 miles on the other, combined with curves of 600 ft. radius, with other portions still more severe. The Pennsylvania Railroad crossed the same range at about 2,160 ft. elevation, with gradients originally of 1 in 37 and 1 in 49, combined with curves of 345 ft. radius. The Erie Railroad was originally laid out with extreme care to secure the best grades and curves over the whole line; to get over a summit of 1,374 ft., heavy expenses were incurred in making the maximum grade 1 in 88. The New York Central had a maximum grade of 1 in 56, with sharp curves; but its late rival, the West Shore, secured west-going grades of 1 in 264, and east-going ones of 1 in 176, with curves of 1,146 ft., 1,274 ft., and 1,432 ft. radius. Other important lines in the same regions made free use of steep grades and sharp curves.

The Pacific roads all used steep grades when required. The Southern Pacific Railroad had several miles with 1 in 46; the Union Pacific 1 in 59; the Central 1 in 46, which was also used by the Canadian Pacific in one continuous slope 18 miles long, with frequent curves of 574 ft. radius. Where the Atchison, Topeka, and Santa Fe Railroad crossed the Sangre-de-Christo range, trains weighing 200 tons exclusive of engines were run at the rate of six miles an hour up a grade of 1 in 166 combined with curves of 359 ft. radius.

For the most economical railways of standard gauge the steepest grades were resorted to, and in this the American practice agreed with the theoretical studies of Mr. De Freycinet. The most eminent and experienced American engineers, however, attached more importance to the free use of curvature, even of great sharpness, in attaining economical construction for cheap lines.

Of narrow gauge lines no finer specimens could anywhere be found than in Colorado, where the Denver and Rio Grande and the Union Pacific branch line climbed mountains and traversed canyons with precipitous rocky sides with the utmost boldness and success. The former line had opened out the wild but rich mining regions with 1,650 miles of 3 foot gauge line, in the last few years, while the other was still spreading many hundred miles of the same gauge through similar country. On the Denver and Rio Grande line, there was one gradient of 1 in 22, several long ones of 1 in 25, combined with curves of 240 feet radius, and in one case of 193 feet. Passenger trains, sometimes of seven or more cars, were run over the passes, with double-headers of one Mogul and one Consolidation engine; but freight trains, with maximum loads of 246,000 lb., were taken over by three Consolidation engines, each weighing 70,000 lb.

It was evident that all saving in first cost of a railway by the retention of features disadvantageous in operation must result in greater expense of working afterward; and it had been a matter of careful study in America to determine what equivalents the sacrifice of one or more of the qualities usually thought necessary in a perfect railway required, to justify such expedients being resorted to.

The author cited, as one of the best examples of an economical railway on a large scale, the Chicago, Milwaukee, and St. Paul Railroad. This had nearly 5,000 miles of line, and was thus the largest private concern in the world. In 1888 it carried 4,501,000 passengers a total of 235,579,000 miles, and its freight traffic was 1,177,000,000 ton-miles, the rates being 1.26*d.* and 0.695*d.* per passenger-mile and per ton mile. Its equipment consisted of 637 locomotives, about 500 passenger and other coaches, 19,734 freight cars, etc. It owned coal mines, from which it took some 500,000 tons yearly, and was completely furnished with expensive terminal facilities in the great cities, with several workshops, warehouses, elevators, and docks. Steel rails were rapidly replacing iron, where these still existed. With respect to this railroad, Mr. Whittemore, late President of the American Society of Civil Engineers, who had been in charge of the line for forty years, had informed the author that, as an organization, it commenced with but 45 miles, and by consolidation with and purchase of bankrupt lines grew into large proportions. In 1878, its funded debt of all classes of stock and bonds amounted to about 7,600*l.* per mile. Since then, 1,613 miles had been constructed, all standard gauge, at a cost, equipped for business, of from 3,000*l.* to 4,000*l.* per mile, so that now the funded debt was slightly less than 6,000*l.* per mile. At least three-fourths of the distance of 1,600 miles has been into unsettled country and pushed in advance of civilization, which, however, followed within one year after building, and all the lines paid expenses of operation within one year after completion. As the demands of remunerative business warranted, permanent improvements in the railway were made. Whenever 40 per cent. of the gross earnings would pay the interest of the funded debts, then generally the balance, after paying operation, was expended in such improvements. In the first instance, all the bridges were constructed of wood. In the 1,000

miles of line built since 1877, there were probably not more than 3,000 cubic yards of masonry. The earthwork was about 15,000 cubic yards per mile. The timberwork for pile and trestle bridges and culverts, exclusive of truss bridging, would be 1 foot board measure to a cubic yard of earthwork. Truss bridging amounted to one 100 ft. span to each ten miles. On the entire line there were 94 miles of all kinds of bridging (pile, trestle, and truss), or two per cent. of its entire length. The average life of wooden culverts and pile and trestle bridges was from eight to ten years, and of truss bridges nine to eleven years. In new structures the limit in tension was 10,000 lb., but in hanger bolts liable to shock, from 4,000 lb. to 5,000 lb. The link-and-pin bridges in iron and steel in universal use in America would not well admit of additional members being added, as the freight tonnage increased, to provide additional strength. The large American railway systems generally found it preferable to distribute a number of shops over the lines to having them concentrated. Every branch of construction of cars and locomotives, as well as repairs, was carried on in them; but it was the practice, as far as possible, to have separate articles made in special factories to standard forms and strengths, which was found at once cheaper and better than each place making everything for itself. On the Chicago and Milwaukee principal lines the stations were three to four miles apart, and on the rest about seven miles apart. Sidings were laid for passing trains where, as in most cases, the track was single. The Pennsylvania, with 70 per cent. of side track, passed fifty-one trains, passenger and freight, over its trunk lines both ways daily.

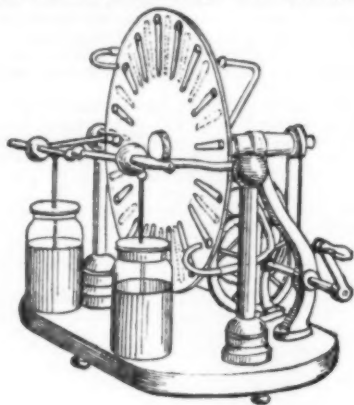
The author had come to the following conclusions:

1. That there was no difference in the principles underlying the American practice in the location of light railways and that of the most expensive and perfect railway for heavy traffic; and that while the former was to be looked upon as an imperfect stage of development of the latter, due consideration was usually given and provision made for the growth and improvement of the line to a more complete and perfect stage as traffic increased, with the least possible fundamental alteration in the line or its belongings. The very highest engineering skill was as much or more required in laying out a cheap and light line as a heavy line. 2. The latest and best American practice rejected the use of very light rails and permanent way. It must be prepared for the ordinary passenger and freight cars of the country to pass over it, the only difference being that lighter loads would be carried on the light line. To fix the ideas, without attaching value to the figures, it might be expressed by saying that while 3,000 lb. per lineal foot of train appeared to be the maximum load of a freight train on a heavy road at present, 2,000 lb. per lineal foot was the limit of the light railway; and the bridgework would be calculated for these loads respectively. Steel rails weighing not less than 55 lb. per yard, with rigid connections, and sleepers not less than 2,800 per mile, with 15,000 square feet of bearing surface on the ballast, should be used. 3. The nature and amount of traffic to be provided for being fixed, a variety of opinion and practice appeared to exist as to the mode of working it. Thus, some advocated light engines and a larger number of trains in order to facilitate and encourage the growth of traffic, while others preferred heavier engines and fewer trains, with greater loads, as being by far the more economical. In the far West, where distances to be traversed were great and traffic was small, very few trains, sometimes one or two only each way per day, were run; and here were some of the heaviest engines in use in the country both on standard and narrow gauge lines, with trains loaded to their fullest capacity. While in the newer countries of the mid West, where settlers were more numerous and movement brisker, it was good policy to run light trains oftener. 4. The practical recommendations of the alignment might be thus briefly summed up: When no extra cost was involved by it, the same grading and curvature that could be given to the most perfect railway the country admitted of should be used for the economical line. In undulating country the surface line should be approximated to, and all undulations of not more than 3 ft. might be adopted with ordinary grades without incurring any expense to avoid them. Above that height an expenditure of from 20¢ to 100¢ for each vertical foot might be incurred to avoid the undulation. Where it was necessary to resort to stiff grades, they should be eased off at both ends; and for speeds of 15 to 30 miles an hour the introduction of breaks in the gradient of five vertical feet in height, to allow the engine to get up momentum, were advisable. But where it was possible to get round an obstacle by curves these should be preferred to steep gradients. In the very roughest country a reduction of curve radius from 600 ft. to 300 ft. brought the cost enormously down, while in ordinary rough country curves of 573 ft. and 478 ft. radius furnished the most expedient minimum curves. Local traffic and towns should be served by increasing the length of the line. Trestling should be used everywhere instead of heavy masonry or earthwork of above 10 ft. to 15 ft. in height. Split stringers, sills and caps, without mortises, where every piece could be taken out and renewed without much trouble, should be adopted. Terminal and station facilities should be of the cheapest kind. Level crossings were everywhere used, even in the largest cities, in the United States. Fencing was often dispensed with, except in cattle grazing districts. All these matters were differences of degree and detail rather than of kind or of principle between light lines and substantial for a railway; and the general problem the American engineer set before himself was, not which was the best possibly constructed line for serving any probable traffic permanently between two places, but, of all possible lines passing through a given country, which was the one that, in a series of years after construction (taken sufficiently long to include the period of renewal of temporary works), would give at the same time a minimum of interest on first cost and a minimum of cost of operation of the traffic likely to be developed during that period? All solutions of the problems were given in a more or less tentative form as regarded the data employed and figured conclusions, while the principles remained true throughout all varying applications. Finally the author gave a sketch of the principles and a few of the data relating to American railways, as treated by Mr. Hermann Haupt, Professor G. L. Vose, Mr. William H. Searies, and Mr. A. M. Wellington.

#### IMPROVED WIMSHURST MACHINE.

THE whole of the working parts are fixed to one metal casting, which is so designed that the driving-wheels (also of cast iron) present their edges to the vertical zone of the plates, which lies between the posterior and anterior brushes, and which may be regarded as inert, so that even a conductor presented close to the plates will have no effect in that particular position. The driving-handle is at right angles to the plane of the plates, which is at once convenient and enables the experimenter to stand on one side of the instrument when exhibiting to an audience. In the new form there is but one driving-band, which is adjustable for tension; and as the pulleys are embraced on one half of their circumference, there is no slip, and the plates are driven at equal speed—a condition not easily arrived at when two bands are used, one crossed and the other open.

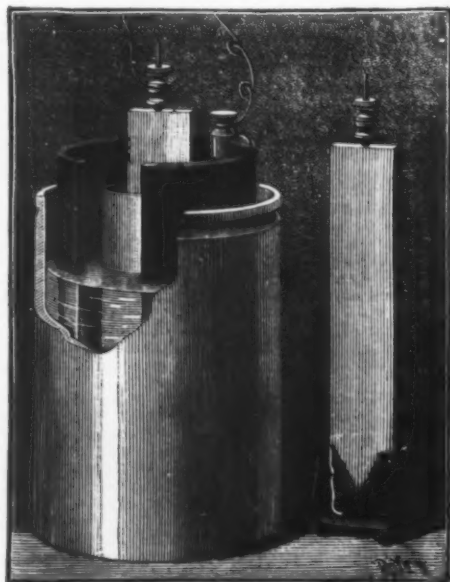
From the top of the casting projects a fixed tubular spindle, on the outside of which the boss carrying the back plate rotates, and through the inside passes the



steel spindle on which is fixed the flange and nut to take the front plate; both the brush holders are fixed at the back of the plates, leaving the front of the machine for the horizontal discharging electrodes and the Leyden jars. These last are better not to be fixed permanently, but capable of removal for wiping and drying, for, although the machine will work in most adverse circumstances, it will be prevented from giving its full length of spark if these are not in good order. It is not claimed as simpler than the ordinary form for the amateur to make; but to those who wish a more permanent and elegant machine it will recommend itself, for, although it looks complex, by undoing three milled heads the whole of the working parts can be taken piecemeal in less time than it takes to describe. —Alex. Spark, Eng. Mechanic.

#### DOMESTIC ELECTRIC LIGHTING.

WE are often asked what system of domestic electric lighting we would recommend. As long as a distribution of electricity to houses is not carried out, we must not, with the present resources of physics, think of practically and economically lighting an entire apartment by means of primary or secondary piles, but we can obtain a momentary, partial illumination that is capable of rendering the greatest services. Our colleague, Mr. Hospitalier, has already, in these pages, described Mr. Radiguet's lighter and extinguisher, and this is the system which we have adopted, and which we now recommend. It is a most ingenious apparatus, since it permits of lighting an electric lamp in a room that we are entering, and at the same moment of extinguishing the one that had just before been lighted in the room that we are leaving. This system



RADIGUET PILE.

is applicable to one room or to the different stories of a house from cellar to garret, and requires the use of but one battery of four or six elements.

We have had a system of this kind put into our apartments, and it has been operating for several months to our entire satisfaction. We shall briefly describe it to our readers, thinking that in so doing we may render a service to those who may desire to imitate our arrangement. A pile of six elements, to be described further along, is placed in a room in our garret. From

this, two wires run to our apartments, and are connected with incandescent lamps located in the different rooms. In the evening, on entering the dark antechamber, a commutator permits us to light up the latter. Then opening the parlor door, we touch a button and light up the room and extinguish the lamp in the antechamber. The same maneuver is performed for crossing our study in order to reach our bed-room. In addition, incandescent lamps are placed in a dark closet filled with books, and in the water-closet, etc. The same pile suffices for all this lighting, although the latter is not continuous, but is only used for a few minutes at a time in one room or another, in order that a match may be found, a visitor shown out, etc.

The pile, which is of the Poggendorf type, consists of an external vessel of glazed pottery of good quality, containing a concentrated acid solution of bichromate of potash, and of a carbon cylinder whose top is paraffined. This cylinder contains a porous cup whose top and bottom are paraffined, and which is filled with water acidulated with  $\frac{1}{4}$  part of sulphuric acid by volume. The zinc which this cup contains remains constantly submerged, and its lower part dips into mercury contained in a cup with sloping sides. It is due to this latter that the zinc can remain submerged without wear in open circuit.

If we were content to pour the mercury into the bottom of the porous vessel, it would not only require the use of a large quantity of it, on account of the concave form of the bottom, but, after a few hours' operation, the mercury would be found to be covered with sulphate of zinc, which would finally adhere to the mercury and zinc, and entirely cover the former metal. At the place where the mercury and zinc were in contact, a kind of soldering would occur that would entirely suppress the said contact and prevent the mercury from entering the pores of the zinc. Mr. Radiguet's cup remedies this trouble; since, as the sulphate of zinc formed slides over the external surfaces, the mercury remains clean and in constant contact with the zinc.

The acidulated water in the porous vessel is changed every fortnight, or after seven or eight hours of lighting. The same bichromate may be used for four charges of the porous vessel, say for about thirty hours, since the lamps consume but one ampere. The six elements of this pile allow us to operate incandescent lamps of three candle power. —La Nature.

#### DYEING ANILIN BLACK ON COTTON PIECE GOODS.

THERE are very few firms capable of producing a good anilin black by dyeing on a cotton cloth; no doubt a good black can be obtained by the same process as used for yarns, but this is very liable to rub, and is also exposed to greening if not properly oxidized. The following method, says the *Textile Manufacturer*, taken from our contemporary, the *Oest. Woll- und Lein Industrie*, will, therefore, be found useful by those engaged in cotton piece dyeing.

The pieces are treated twice in a cold solution containing

Sulphate of copper (bluestone).....  $\frac{1}{2}$  lb.

in Water..... 9 gals.

then brought on the jigger containing

Yellow prussiate.....  $6\frac{1}{2}$  oz.

in Water..... 9 gals.

and worked in this at a temperature of about 140 degrees Fahrenheit.

The pieces are treated twice in this bath, the second time with only half the amount of yellow prussiate.

After washing in cold water, the pieces are dried, when they will be found of a light cutch color, produced by the prussiate of copper, which has been formed during the operation. They are then passed twice either through the padding or through the sizing or starching machine in the anilin bath prepared as follows:

Chlorate of potash.....  $2\frac{1}{2}$  lb.

is dissolved in

Boiling water..... 1 gal.

In another vessel

Tartaric acid.....  $2\frac{1}{2}$  lb.

is dissolved in

Hot water.....  $\frac{3}{4}$  gal.

and both solutions are added to each other while still warm, and then mixed with

Anilin oil.....  $2\frac{1}{2}$  lb.

at a temperature of about 150 degrees Fahrenheit.

After cooling, a further solution is added of

Anilin salt..... 5 lb.

Salammoniac..... 2 lb.

in

Water.....  $2\frac{1}{2}$  gals.

After filtering are added

Water..... 3 gals.

Hydrochloric acid.....  $3\frac{1}{2}$  oz.

and

Tartaric acid.....  $3\frac{1}{2}$  oz.

The pieces, in coming out of this bath, are pressed through rollers in order to squeeze out the excess of liquor, dried, and then hung up in a warm place at a temperature of about 100 degrees Fahrenheit for three days. The goods, which after this time have a greenish tint, are passed through two soda baths, one cold and one at 140 degrees Fahrenheit, containing

Soda ash..... 3 lb.

dissolved in

Water..... 8 gals.

Finally follows a soap bath at 140 degrees Fahrenheit, prepared with

Soap.....  $\frac{1}{2}$  lb.

in

Water..... 10 gals.

Then the pieces are washed and dried.

The black thus produced is said to be very intense, does not rub, can be calendered, and is also not exposed to after-greening. We recommend our friends to try this method, which, it is stated in our contemporary, has given very good results on a large scale.

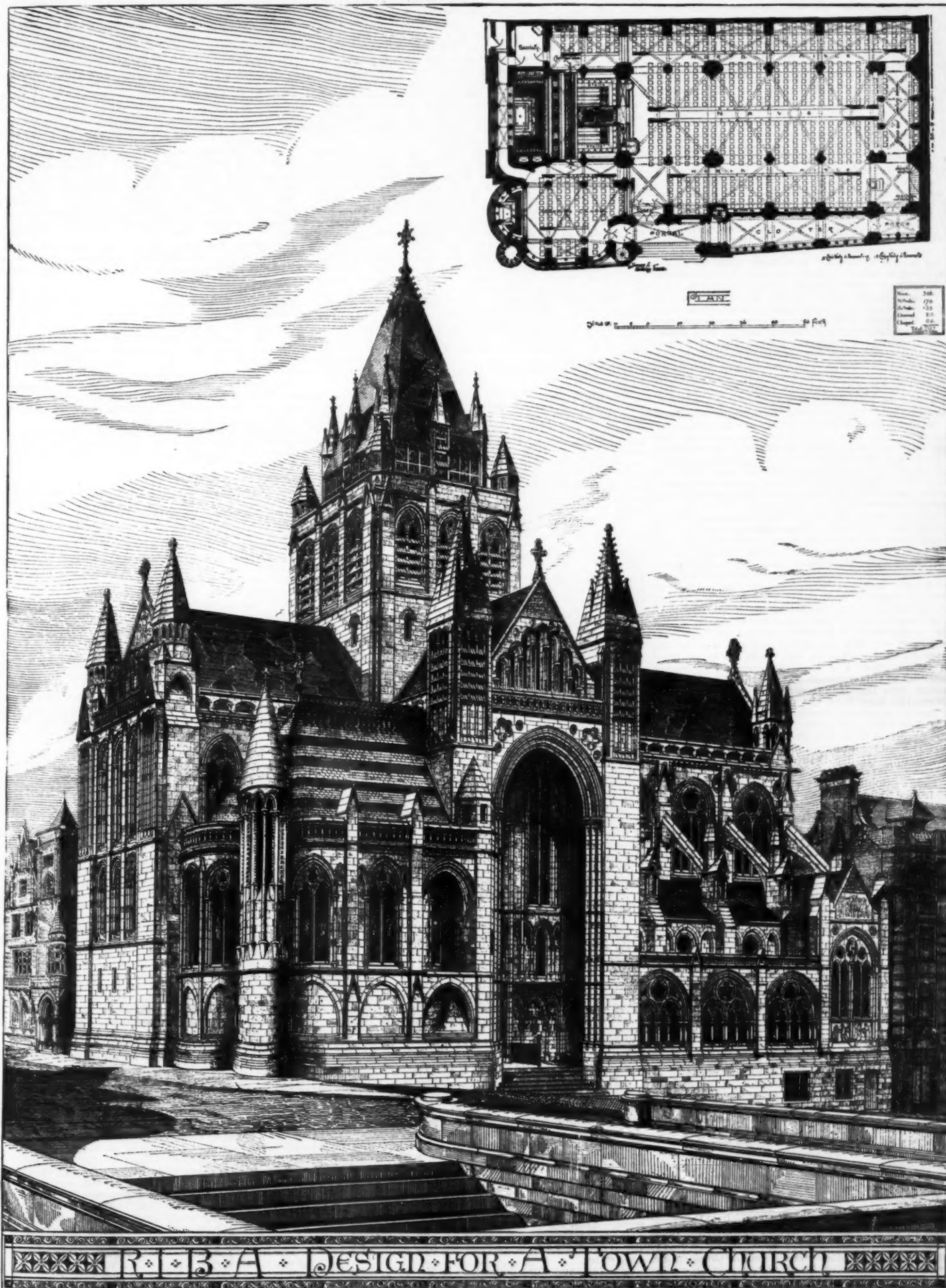
## PRIZE MEDAL DESIGN FOR A TOWN CHURCH.

THIS prize design is the one over which a considerable discussion was held at a recent meeting of the Royal Institute of British Architects, the President, Mr. Ewan Christian, Prof. Kerr, and others contending that particularly for the ability of its plan its author should be awarded the Soane Medallion, for which his design was submitted in the late competition. In this opinion we still concur, and we have much pleasure in illustrating the general view and plan. The Institute awarded a medal to Mr. J. H. Curry, A.R.I.B.A., for this design and the drawings with which it was illustrated.—*Building News.*

## WHAT CAN BE DONE ON A BICYCLE.

A HARTFORD (Conn.) paper gives the following report of the performances of an expert on the bicycle: He showed some wonderful things that may be done with a bicycle. Before he got through with his exhibition no one would have been surprised if he had thrown aside the wheel and ridden around on the air where it had been. His best feats were: Riding with small wheel off the ground; backing with small wheel off the ground; swinging in small circle on the big wheel only; facing backward and riding forward; standing up on saddle; sitting on saddle, the machine being still and balanced; machine upside down, mount the big wheel,

turn the small one over into place, and start off; removing the small wheel, ride the large one backward or forward; lay handle bar on the ground, mount big wheel, reach over and get the bar, and start off. He succeeded on the third trial, and was cheered. Then he removed the handle bar, leaving only the big wheel, which he rode. Next he removed the treadle from the big wheel, and, mounting, propelled it with his hands. Next he stood upright, hands in air, and rode the wheel. Then he brought out a common wagon wheel, placed his feet on the hub on either side, and propelled it with his hands. He closed by laying the wheel flat on the ground, suddenly pulling it upright, springing on, and riding away.



## THE THEORY OF PROPORTION.

A LECTURE to students of the Royal Academy, on proportion, was lately given by Mr. W. Watkiss Lloyd, who took as his special topic "An Exposition of the Theory of Proportion in Architecture as understood and applied in detail by the Architect of the Parthenon." Mr. J. E. Hodgson, R.A., occupied the chair. The temple of the Parthenon, the lecturer remarked, was built entirely of white marble in large blocks, without the use of a particle of mortar, the stones being held together with lead clamps, and so accurately were the joints fitted together that it was impossible to insert a penknife between them. How the blocks could have been set so closely together was still a puzzle to architects. The construction was trabecated, no arches being employed; the vertical joints in the architrave were made to fall just over the columns, and were covered by the middle of the triglyph, which in turn bore the weight of the cornice. The columns were built up of drums cut as frusta of cones, and ground together to insure accuracy of fit, the flutings being executed after the columns were set up *in situ*. The architect of this temple knew that all horizontal lines of any extent seemed to bow down in the center, that two vertical lines placed near together appeared to incline toward each other at the upper portion, and therefore he devised an elaborate series of refinements to correct this optical effect. There was as a matter of fact not a single truly horizontal or vertical line of any appreciable length in the whole temple; every apparently horizontal line was given a slight upward curvature, and the lines of the columns sloped toward the center of each front, besides having an entasis given to their outline.

The joints of the drums of columns were horizontal, with the exception of the base of the lowest drum, which was curved upward to suit the line of the pavement on which it stood. Architects were for a long time somewhat loth to admit that such delicate refinements could have been adopted by the Greeks, but the exact measurements made by Mr. F. C. Penrose had proved the accuracy of the statements made by ancient writers. Mr. Penrose's series of measurements was made independently of any theory, and he was, therefore, an impartial witness both with regard to the optical refinements and the method of proportioning adopted in this building. In his previous lecture on the subject of proportions he had endeavored to show them that the Greeks adopted relative proportions, which could be expressed in ratios of low numbers; that they adhered in any given building to a scale of ratios selected from such low numbers; that the scale was employed to very diverse purposes and arts, and in buildings to vertical and horizontal lines of both large and small dimensions; that a controlling principle was that the proportional numbers were to be expressed in terms which were in their nature correlative—a series in which in every term the numerator and denominator differ by the same number.

The special scale adopted in the Parthenon temple, he should show, was one of low ratios, the differences of which were expressed in terms of 5; thus 1 to 6, 2 to 7, 3 to 8, and 4 to 9 were very useful proportions in the building. The Parthenon had eight columns on the east and west fronts, but on both the north and south flanks were 17 columns; at the Temple of Minerva we found 6 columns on the chief fronts, and 13 on the flanks, while at Bassæ there were 6 and 15 columns respectively. The absolute term on which all the proportions of the Parthenon were based was the length of the top step of the east and west fronts, which was exactly 100 Attic feet; and we knew from classic writers that a certain traditional importance was ascribed to this dimension. Another name for the Parthenon was the Hekatompedon, derived, it was said, from the fact that the naos or principal apartment, that containing the seated statue of the goddess, was 100 feet (Attic) in depth. The first problem before the architect of the Parthenon was to arrange the width of the intercolumniation, 6 on each front and 16 on each flank. He decided to adopt a proportion of 4 to 9 between fronts and flanks, the same as that employed in the Temple of Bassæ, while other large temples ranged from 4 to 8 to 4 to 10. The length of the flanks, as measured by Mr. Penrose, was 238.017 Attic feet, showing a deficiency of 0.124 ft. on the exact proportion. This inaccuracy of 1½ in. on the length of a building like the Parthenon seemed very little to us, but was exceptionally large when compared with other dimensions. Having arranged the relative length to the standard breadth, the next point was to determine the full height of the building. The height of the naos was to some extent regulated by that proposed for the colossal figure. After comparison, analysis, and thought, he decided that the full height from pavement to apex of pediment should be to the width of front as 9 was to 14. This gave a height of 65.147 Attic feet, whereas the actual dimension was 65.185, an error in excess of less than half an inch. Such phenomenal exactness proved that these ratios were actually and deliberately adopted, for these figures of dimensions were published long before the lecturer propounded his theory. Some extraordinary coincidences might be anticipated in any building; but that every dimension would bear a relative proportion to a certain scale of ratios was not to be expected unless the designer had such a system in view. He had now shown that the outer framing, the length, breadth, and height, fell into a series of normal ratios separated by the constant number 5. The next most important point to be decided was the relative proportion to be assigned to the space between architrave and basement and the joint height of columns, architrave, and pediment. Should the column and full height of building be divided equally, or, if not, to which should the predominance be assigned—to the columns or to the pediment and its supports? Lightness and vivacity were secured by giving to the column more than half the full height, and these were allied to elegance.

Ancient temples varied in proportions of column to full height of pediment from ratios of 2 to 1, or 3 to 3, to those in which there was almost an equality. The Ionic temple of Priene showed proportions of 3 to 1, and most Ionic buildings were of similar proportions, where in the Temple at Bassæ the proportion was as 6 to 7. The proportion of 2 to 1 was the limit of lightness, and in some Ionic temples so planned the capital and base were so flatly proportioned as to appear to belong to the entablature and stylobate respect-

ively. The Athenian architects were the first to give a decided predominance to the vertical members of the composition, and in the Parthenon the proportion adopted for the column was 10 to 9 of the full height, or 34.30 Attic feet, which agreed with the actual dimensions within half an inch. The remaining nine parts of the nineteen into which the height was divided were allotted to the basement, entablature, and pediment.

The next important part was the extent of the relative masses and spaces of the columns, a matter which governed the thickness of the columns, and which involved the delicate proportioning of solid to void as the question of height just determined. Spaciousness was favored by making the openings largest, while the opposite treatment made the building seem compact. Not only had sufficient passage way to be provided between the columns, but the appearance of freedom for movement had to be presented to the eye. The proportion adopted for voids and solids at the Parthenon was 15 to 12, whereas at Bassæ the openings were as 16 to 12, and in smaller temples they were relatively much larger. The setting out of the columns was complicated by the fact that the angle columns had to be rather stouter and to be set rather more closely than the others, in order to maintain the apparent strength and also because space had to be provided for a full triglyph at the end of the architrave.

The normal intercolumniation was found to be absolutely accurate to the last decimal place with regard to every third stone, suggesting that the work was set out for every third stone, and nowhere was the variation equal to ¼ in. By setting out the work in threes the designer would prevent any error from becoming cumulative. The next point was to the scheme of proportion adopted for the column itself, and here there had to be considered not only its diminution from base to capital, but also the subtle entasis given to it to correct the optical effect of apparent want of substance in the upper third. The relative thickness to height, judged by diameter of the lower third, was as 4 to 9, and the normal diminution was ⅓ of total height. The abacus was one-fifth of the height of the column, and in width one-fifteenth of the chief fronts. The leading dimensions of the Parthenon were nicely adjusted to those of the human figure, so that persons passing in and out appeared of the normal height, and did not dwarf the building, nor were dwarfed by it.

The three steps by which the temple was raised above the Acropolis were, however, much too high for easy ascent, being, in fact, a podium, and so little steps were provided in certain places for access. The rectangular mass under the cornice and above the podium had the proportion of 4 to 9 with an unappreciable error of 0.0034. The breadth of the top step of front bore the relationship to the height from pavement to top of pediment of 7 to 12, following the same law of ratios as that observed elsewhere, that all were separated by 5, and were reciprocal. The height assigned to the entablature and basement in proportion to the columns on the flanks where no roofing was visible was as 1 to 2, the columns being thirty-four feet high and the entablature and steps 17 ft. This relation could be no merely accidental coincidence, for the sure proportion of columns to entablature and base was observed in another great Athenian temple, the Theseum, and also in those of Bassæ, Rhamnus, and Sunium. These analytical ratios of proportion were, he was desirous of pointing out, matters of pure speculation, based upon the fact which had come down to us that the Greeks possessed some such system; but they left us, he thought, filled with wonder at the manner in which they contrived to bring in so many mutually dependent proportions and yet give to the temple such unequalled dignity and beauty.

In the proportionate distribution of the dimensions of the cells of the Parthenon the differences were very slight, and yet they all followed the law of ratios. The architect appeared to have a horror of the mere multiplication of parts in rigid proportions, and yet seemed to have sought not to make the variation too obvious. The general rectangle of the cella had a ratio of 7 to 19. From the west end or rear an exact square was cut off for a treasury, and the naos and pro-naos were left with the normal proportions of 7 to 12. So that the same ratio which governed the general height of the temple was here repeated horizontally. The height of the naos was, as already noticed, the same as the breadth of the front on top line of podium, 100 ft. The upper part of the naos had been destroyed; but it appeared to have been equivalent to a ratio of 4 to 9 with the length of side walls, and of 11 to sixteen to the end wall.

He had not by any means exhausted the examples of ratios to be found in the Parthenon, but had only given illustrations of the main points, and he would refer any students interested in pursuing the subject to his appendix to Professor Cockerell's work on "Asia Minor," published by the Dilettanti Society. In order to perfect this lesson of the value of proportioning to the highest art, it would be desirable to examine the relative observance of the system by mediæval and modern buildings, and to consider how far their success or failure as works of art depended upon their adherence to the rules of proportion.

## LUMINOUS PAINTS.

The luminous calcium sulphide which is now found in commerce has a yellowish tinge, which essentially prevents its direct use as a paint. On the other hand, calcium sulphide, or the luminous paint prepared from it, loses its luminous properties when it is directly mixed with commercial paints. Its preparation is as follows: Oyster shells are cleaned with hot water, heated in a fire for half an hour, allowed to cool, and finely pulverized. The gray particles, which are of no value, are removed. The powder is placed in a crucible, in alternate layers with sulphur. The crucible is covered and luted with a thick paste made of beer and sand. After the crucible has been ignited for an hour and cooled, its contents are white. The resulting powder is carefully sifted, and ground to a paint with gum and water.

It is luminous for a long time in the dark, after having been exposed to daylight. An invention recently patented by Schade, in Dresden, has for its object the preparation of a durable white or colored paint, containing a luminous body, by means of which the paints

are rendered luminous in the dark without changing the shade of their color during the day.

This is effected as follows: Zanzibar or Kauri copal is melted over a charcoal fire. Fifteen parts of the melt are dissolved in 60 parts of French oil of turpentine and the filtered solution is mixed with 25 parts, previously heated and cooled, pure linseed oil. The varnish which is thus obtained is used in the following methods, in the manufacture of luminous paints, by grinding between granite rolls in a paint mill. Iron rolls should be avoided, because particles of iron, which are liable to be detached, would injure the luminous properties.

Varnishes, as they occur in commerce, generally contain lead or manganese, which would destroy the phosphorescence of calcium sulphide. A pure white luminous paint is prepared by mixing 40 parts of the varnish, obtained in the above described process, with 6 parts prepared barium sulphate, 6 parts prepared calcium carbonate, 12 parts prepared white zinc sulphide, and 36 parts good luminous calcium sulphide in a proper vessel, to an emulsion, and then grinding it very fine in a color mill. For red luminous paint, 60 parts varnish are mixed with 8 parts prepared barium sulphate, 2 parts prepared madder lake, 6 parts prepared realgar (red arsenic sulphide), and 30 parts luminous calcium sulphide, and treated the same as for white paint.

For orange luminous paint, 46 parts varnish are mixed with 17½ parts prepared barium sulphate, 1 part prepared Indian yellow, 1½ parts prepared madder lake, and 38 parts luminous calcium sulphide.

For yellow luminous paint, 48 parts varnish are mixed with 10 parts prepared barium sulphate, 8 parts barium chromate, and 34 parts luminous calcium sulphide.

For green luminous paint, 48 parts varnish are mixed with 10 parts prepared barium sulphate, 8 parts chromium oxide green, and 34 parts luminous calcium sulphide.

A blue luminous paint is prepared from 42 parts varnish, 10½ parts prepared barium sulphate, 6½ parts ultramarine blue, 5½ parts cobalt blue, and 46 parts luminous calcium sulphide.

A violet luminous paint is made from 42 parts varnish, 10½ parts prepared barium sulphate, 2½ parts ultramarine violet, 9 parts cobaltous arsenate, and 36 parts luminous calcium sulphide.

For gray luminous paint, 45 parts of the varnish are mixed with 6 parts prepared barium sulphate, 6 parts prepared calcium carbonate, 0.5 part ultramarine blue, 6.5 parts gray zinc sulphide.

A yellowish brown luminous paint is obtained from 48 parts varnish, 10 parts precipitated barium sulphate, 8 parts auri pigment, and 34 parts luminous calcium sulphide.

Luminous colors for artists' use are prepared by using pure East India poppy oil, in the same quantity, instead of the varnish, and taking particular pains to grind the materials as fine as possible.

For luminous oil color paints, equal quantities of pure linseed oil are used in place of the varnish. The linseed oil must be cold pressed, and thickened by heat. All the above luminous paints can be used in the manufacture of colored papers, etc., if the varnish is altogether omitted, and the dry mixtures are ground to a paste with water.

The luminous paints can also be used as wax colors for painting on glass and similar objects, by adding, instead of the varnish, 10 per cent. more of Japanese wax, and one-fourth the quantity of the latter of olive oil. The wax colors prepared in this way may also be used for painting upon porcelain, and are then carefully burned without access of air. Paintings of this kind can also be treated with water-glass. The latest use made of luminous paints in England is the painting of harnesses, which is said to produce quite surprising effects in nocturnal driving.—Ztschr. Oest. Ap. Ver.

## CONCRETE.\*

I HAVE to-night to ask your attention to the means to be adopted for rendering buildings stable, and securing good foundations. This question of foundation is perhaps the most essential of any with which persons connected with buildings have to deal, for if the foundation be faulty, the superstructure, even if it should stand, will certainly suffer. It will be totally useless for the architect to design, or for the deft fingers of the mason to elaborate, the most delicate window-tracery, the most graceful piers and columns, the most stately towers and domes, or for the artist to enrich these creations with the most brilliant efforts of his genius, unless the edifice be founded so that no cracks or settlements occur to deface the decorations. In some localities, as, for instance, where rock crops up close to the surface, a natural foundation is obtainable which cannot be improved upon; but in the majority of cases, and especially in London and its neighborhood, it is almost impossible to find a good natural foundation without digging to a depth that is practically out of the question, on the ground of expense. Hence it is necessary to form artificial foundations, and the material principally used for these is concrete.

Although the use of concrete as a building material is of comparatively recent date in this country, it was known and extensively used by many of the nations of antiquity. There is ground for thinking that the Greeks were not unacquainted with its use, especially in the Italian colonies of Magna Græcia; and as far distant as Mexico, in many of those curious pyramidal buildings which are the remains of an unknown civilization, concrete foundations have been discovered. But when we come to those grand old builders, the Romans, who were, *par excellence*, the scientific constructors and engineers of ancient times, we find that they used concrete to an extent with which nothing that has as yet been done in modern times can compare. One reason for this was that the Romans found ready to their hand the best materials that exist in the whole world for making good concrete, viz., the travertine limestone, the pozzolana, which is a fine sandy earth of volcanic origin, and a beautiful clean, sharp sand.

The use of concrete by the Romans dates back as far as the time of the Kings—i. e., anterior to 509 B.C.; and no less than five kinds of concrete walls are described by Prof. Middleton, who has recently devoted

\* By John Slater, B.A., F.R.I.B.A. A lecture delivered at Carpenters Hall on Wednesday night, March 17, 1886.—Building News.

a great deal of careful attention to the methods of construction of the Romans. In addition to using concrete for foundations, they used it without any facing for walls, which were constructed very nearly as described in Mr. Tall's or Mr. Drake's patents, which were taken out a few years ago. Wooden posts were fixed in the ground about 3 ft. apart, and boards were nailed horizontally to the posts, and then the intermediate space was filled in with concrete in a semi-fluid state, and as soon as this had set, the boards were moved one stage higher. Thus the concrete formed one perfectly solid mass, and some of these early Roman walls are so solid and hard still that quite recently it has been found necessary to destroy them with dynamite in the course of improvements that have been made.

Even when the Roman walls appear to be of brick or marble, this is in every case a mere facing or veneer, and the core of the wall is of concrete. They also largely used this material in constructing very extensive vaults, for supporting upper floors, staircases, ranges of seats, etc. Concrete also formed the basis of all Roman roads; in the early examples the blocks of stone laid on the concrete were much more closely jointed than was the case afterward. There can be no doubt that the lasting nature of the Roman concrete was due, in addition to the excellent materials, to the careful way in which it was made, and I shall have to refer again to the method of making concrete adopted by the Romans. The French have been very great users of concrete, or *béton*, as it is there called, since the year 1820, and the material has been used in enormous blocks in docks at Toulon, Marseilles, and other places, and in the construction of the mole at Algiers and the breakwater at Cherbourg. In this country concrete was employed in very early times, as, for instance, in the foundations of Westminster Abbey and in the older portions of the substructure of St. Paul's; but its use died out, and for a long while the only method adopted for making stable artificial foundations in bad soils was pile-driving.

Although Mr. Sempie, of Dublin, in 1776 suggested the use of a mixture of sand, gravel, and quicklime for structural purposes, it was not till the beginning of this century that concrete was recognized as a building material. Colonel Pasley says that the first use of concrete for foundations was by Mr. Smirke at the Millbank Penitentiary in 1817, and there is a story that the discovery, or rather rediscovery, of the fact that lime would combine with gravel and form a sort of artificial stone was a pure accident, owing to the upsetting of a barge-load of lime during the erection of Waterloo Bridge, when it was found that the loose gravelly bed of the river had been rendered hard and compact by the action of the lime. Now, what is concrete? It may be defined as an artificial stone composed of a mixture of hard materials, such as ballast, flints, stone chippings, broken bricks, pottery, or iron slag, called the "aggregate," and a cementitious material, called the "matrix," thoroughly combined, together with a sufficient quantity of water.

The value of the concrete depends almost entirely upon the quality of the cementitious material, whether lime or cement, and it is most important that you should clearly understand the difference in the properties of various kinds of lime. I must make a short digression here in order to describe them. You are, of course, all aware that lime is produced by burning limestones, and upon the constituents of the limestone depends the quality of the lime. First, there are the rich limes produced from stones which are perfectly pure carbonate of lime—such as the upper and middle chalk formations and white statuary marble. Lime made from these stones is commonly called chalk-lime, and is much used for mortar and concrete in country districts where chalk is plentiful. This lime, when mixed with water, commences to slake, as it is called—i. e., it swells, hisses, gives off hot vapor, and falls into powder; and if it be then mixed with water, it will always remain of the same consistency, and never harden at all; and as it is soluble in fresh water, mortar made of chalk lime should never be used for external work, as the action of the weather will soon render the joints quite soft, and any one who has been present during the pulling down of buildings, the mortar of which was composed of chalk lime, will have noticed how easily the bricks are separated, and what a large amount of dust comes from the demolition.

Then comes the poor lime, made from the argillaceous or clayey limestones, which contain, in addition to the carbonate of lime, various foreign substances, chiefly silica and alumina, and often a small quantity of oxide of iron. The existence of a small quantity of these foreign substances—as in the Dorking, Halling, and Merstham limestones—causes the lime made from them to show much less violent action when slaked, and enables it to set after slaking, but not under water. Next come the blue lias limestones, which contain a greater quantity of silica and alumina, and produce what is called hydraulic limes, which will set and continue to harden under water; and after these come the so-called natural cement stones found in the London clay formations at Harwich, Sheppey, and the Isle of Wight, or in parts of Yorkshire, in the clays of the oolitic series. These contain even more silica and alumina, and from them used to be manufactured the Medina and Roman cements, which had the power of hardening under water very quickly. These cements enjoyed a high reputation for many years, but they are now almost entirely superseded by the artificial cements of which Portland is the type. You may take it roughly that rich limes contain over 90 per cent. of carbonate of lime; graystone limes, such as Dorking, about 80 per cent.; blue lias from 66 to 70 per cent., and cements 40 to 50 per cent. When it was a well-ascertained fact that for building purposes lime obtained from the limestones containing a considerable proportion of argillaceous earth was the best, the idea began to gain ground that an artificial cement could be manufactured by mixing chalk with various kinds of clay and calcining the mixture.

The first patent granted for the manufacture of an artificial cement of this kind, called Portland cement, from its resemblance, when set, to Portland stone, was taken out by a Mr. Aspdon, in 1824, who describes himself as of Leeds, in the county of York, bricklayer; but the manufacture was not placed on a really scientific basis till Colonel Pasley carried out his elaborate series of experiments during the years 1826 to 1836. As so often happens with scientific discoveries, it appears to have been by pure accident that he discovered, after many

failures, the superlatively good qualities of the alluvial clay or mud of the lower basins of the Thames and the Medway. This clay, which has been deposited in the tidal waters of these rivers, contains exactly the right proportions of silica and alumina for combining with the chalk. It would take too long to describe in detail the manufacture of Portland cement; but briefly it is this: the chalk and clay, in the proportion, as a rule, of about 70 per cent. of the former to 30 per cent. of the latter (though these proportions vary with the nature of the chalk), are ground under rollers and intimately mixed together with a great quantity of water until the mixture is of the consistency of thin paste, which is allowed to settle, the water is drawn off, and the residue is left to dry. This is then cut out in lumps and taken to the kilns, where it is burnt at a high temperature, and it is very important that the whole of the mixture should be thoroughly burnt.

The effect of the burning is to drive off all the carbonic acid gas, and to leave the mixture in the form of clinkers. These are then carefully ground to a powder under millstones, to such a degree of fineness that it will all pass through the meshes of a sieve having 625 holes to a square inch. The weight of the ground cement should be as nearly as possible one cwt. per struck bushel, and the specific gravity 3.00. The essential difference between lime and cement is that lime slakes with the addition of water, while cement does not; lime powder, after slaking, will not set if mixed up with water, unless sand is added to it, while cement will set at once, and equally well in the water and the air. The property of setting quickly, and setting under water, makes Portland cement of the greatest value, and its use for concrete is extending every day. Now, with regard to the aggregate, this may consist of ballast, stone chippings, broken bricks, etc., but the latter should never form the whole substance of the aggregate, and care should be taken that the pieces are not too large. In the case of ballast, it is most important that it should be clean and free from any admixture of loam or earthy substances. And there is one other point to be remembered, which is, that the concrete will be much stronger for the admixture of a small quantity of sharp sand, which will fill up the interstices between the pebbles, etc., and will make a much more solid mass of the whole.

Having thus described the materials of which concrete is composed, I now come to the mixing process, and this is a matter which is far too often neglected. We all know the good old rule of thumb way in which ordinary builders' laborers mix up the concrete; a heap of ballast and broken bricks is piled up, a certain, or rather very uncertain, quantity of lime is poured out on it from a sack; then water is added according to the discretion of the mixer, and the mass is quickly turned over and wheeled or shot into the trench; and a very superficial examination is often sufficient to show numerous nodules of unslaked lime after it has been thrown in. Now, this is a most unscientific and improper way of preparing concrete; the great essential is that the lime should all be perfectly slaked during the mixing of the concrete before it is thrown into the trench, and that exact proportions should be maintained. For ordinary foundation purposes, if what is called stone lime be used, two measures should be prepared, the cubical contents of the one being four times that of the other. The large measure should be filled with ordinary ballast, and turned out on a bordered platform; to this should be added a small measureful of sand, and then a small measureful of lime. This will give the proportion of five parts ballast and sand and one of lime; and if this be well mixed and turned over after the water is added, which should be done gradually and in small quantities, it will make a very good concrete for ordinary purposes.

If the ballast and sand before the admixture of the lime amount to a cubic yard, it will be found that about 30 gallons of water will be required to mix it thoroughly. This mixture should be then wheeled and thrown into the trenches, not from a great height, as used to be considered essential, for, if so, the heavier particles tend to fall to the bottom first, and the mixture will not be so well amalgamated, leveled, and rammed. The French method of making concrete or beton, which is almost exactly the same as that adopted by the old Romans, is undoubtedly superior to ours. They invariably mix up the lime and sand to form good mortar first, and then mix in the pebbles with it. A heap of good stiff mortar is first prepared, with a moderately hydraulic lime and sharp sand; a barrowful of pebbles, which have been washed, are then spread out on a platform; over it is spread a barrowful of mortar, then a second barrowful of stones, and then another of mortar, and the whole is turned over with spades, and dragged backward and forward with rakes till the pebbles have become thoroughly enveloped in the mortar, and the whole mass is then thrown into the trenches.

An extra precaution against deterioration of the concrete by contact with loamy earth is adopted in the best work by covering the bottom of the trench with a thin layer of sharp sand. The washing of the ballast is an excellent thing, as it tends to clear it from any earthy particles that may have become mixed with it. There can be no doubt that this is a far more scientific method of making concrete than the former. If the mortar is well made, you get the pebbles more thoroughly amalgamated, and you insure that the lime shall be thoroughly slaked before the concrete is spread; but it is also more expensive, and I should not consider it necessary to use this method in ordinary cases. But where the soil is very wet, or in any case where the stability of the foundations is of very great importance, I should always recommend the use of cement concrete.

With ordinary care in mixing this, supposing the materials are of good quality, you know you can rely upon its setting quickly, and forming a perfectly solid foundation, and you need be under no apprehension of having it spoilt by the inroad of water. The cost is more than that of lime concrete; but not so much more as the difference in cost of lime and cement, because you can use less cement proportionally.

#### CEMENT CONCRETE.

Six parts of ballast, one of sand, and one of Portland cement will make a concrete good enough for almost anything in the way of foundations. Care should be taken that not too much water is used. Faraday, the eminent chemist, said that in the production of con-

crete the great thing was the discreet and accurate use of water. If too much be used, it will wash the cement away from the particles of the mass before it has time to become thoroughly indurated. If the trench in which the concrete is to be spread is not too deep—that is, not above 18 in.—my own opinion is that you will get a harder and more solid mass by filling it up at once to the full thickness, and not putting the concrete in layers; but if you have to put the concrete 5 ft. thick, it must, of course, go in layers. In any case, it will be much improved by being well rammed after leveling. In such a material as concrete there must be a number of minute air spaces.

You can see them with the naked eye in concrete that has set, and the act of ramming will drive out much of the interstitial air, and make the particles of the mixture more compact; and the denser such a material is, the stronger it is. Numerous experiments have been made to ascertain the loss of bulk in making concrete. Professor Hayer Lewis found that 27 cubic feet of Thames ballast, mixed with  $4\frac{1}{2}$  cubic feet of lime and 40 gal. of water, made exactly one cubic yard of concrete; and in some tests made by the Royal Engineers, it was found that 27 cubic feet of broken stones, 9 cubic feet of sand,  $4\frac{1}{2}$  cubic feet of Portland cement, and 25 gal. of water exactly made a cubic yard. The difference between the two experiments may be accounted for entirely by the presence of the sand in the latter case, because the probability is that if a measure containing a cubic yard were filled with broken stones or ballast, it would still hold 8 or 9 cubic feet of fine, sharp sand, because the pebbles would not lie close. It is sometimes stated that concrete expands after being mixed. If it does, it is because it has been improperly mixed, and any expansion that takes place after mixing can only cause some disintegration to take place.

Hitherto I have spoken of concrete as used for foundations only; but there are many other purposes for which the material can be employed. I suppose it is not much more than twenty years ago that, building materials and labor being at a very high price, and by no means of very high quality, the idea began to gain ground that concrete might be used for the walls of buildings. I have already alluded to the fact that the Romans used it for these purposes, and that, too, although they only had lime, whereas we have Portland cement. But the mixing of the pozzolana, which I have previously mentioned, with the lime gave it many of the characteristics of a cement. The Italian architect Palladio, writing three hundred years ago, gives a very good account of the Roman method of wall construction.

He says: "The ancients used to make walls called 'reimputa'—i. e., filled up with ragged stones—which is also called coffer-work, taking planks and planting them edgewise in two rows, distant from one another the thickness of the walls, and filling the space between them with cement, stones of all sorts, earth and mortar mingled together, and so on from course to course." This method of using concrete for walls is called monolithic, the concrete being simply poured in a semi-fluid state into the position required, to which it is confined by boards, and it sets in that position, so that the whole of the wall is one compact, homogeneous mass. Another method is to form slabs of concrete by casting it in moulds, and allowing it to set there, and the slabs are then taken out of the moulds and carried to the place required, and used in the ordinary way, just like bricks or stone. The former system, if only ordinary care be taken, makes undoubtedly the strongest work, as there are no joints, either vertical or horizontal, and, moreover, no skilled labor is required in this construction, ordinary laborers being able to mix the ingredients and fill in as required.

Several systems of apparatus have been invented for confining the concrete to the requisite thickness of wall and for shifting the moulding boards from one stage to another, and many of these are of a somewhat complicated character; but it is very doubtful if any material advantage is gained over the simple plan of nailing the boards to upright posts and filling in between. Walls thus constructed are really stronger than brickwork, drier, and more cheaply built; but great care must be taken in the preparation of the concrete—the cement must be of the best, the aggregate must be broken to the proper size, and the whole thoroughly well mixed. If these precautions are taken, the thickness of the walls may be about 20 per cent. less than with brick.

#### LONDON CONCRETE.

The Metropolitan Board of Works, after a long deliberation, have at length announced their intention of sanctioning the use of concrete as a building material for walls in London, and place the following restrictions on its use, viz., that the proportions shall be one part of cement, two of sand, and three of coarse materials, which may be ballast, gravel, broken bricks or stone, or furnace clinkers; but the coarser materials are to be broken small enough to go through a 2 in. ring. The walls are to be of the same thickness as brick walls, and to be carried up between parallel frames, and the district surveyors are to see that the regulations are properly carried out. I think these regulations too strict as to the thickness of the walls, and as to the proportion of cement, particularly as extensive ranges of buildings have been put up in South-west London where the cement was gauged eight to one. I rather pity the district surveyors in their work of supervision; but the Board seems to have missed the most important point of all—viz., the quality of the cement and they certainly ought to give their officers power to test this, for, as I have pointed out, serious consequences will ensue if this be not of the best kind. The second or block system has, however, some advantages: no particular building apparatus is required; any imperfections in the concrete can be discovered before it is used; the blocks can be made of any required section and of any size, and permanent tints can be given to the blocks by mixing various mineral coloring matters with the aggregate in the moulds. But for laying these blocks, just as much skilled labor is required as is the case with bricks and stone, and, of course, mortar and cement must be used to bed the blocks in, in fact, this is merely using artificial blocks of stone instead of natural ones; but this artificial stone is really concrete, and as such it possesses virtues which may be sought in vain in any of the natural building stones, and therefore no lecture on concrete

would be complete without a reference to the artificial concrete blocks which are very extensively used at the present time.

#### ARTIFICIAL STONES.

I believe the first artificial stone which was used in this country was Ransome's, which was patented in 1844 or 1845. This consisted of a mixture of sand, silicate of soda, powdered flints, and a little clay, which was worked up to the consistency of putty pressed into moulds, dried and burned, and this burning, in my judgment, takes the material out of the category of concrete stones. Some years later, however, Mr. Ransome found that by dipping the moulded mixture into a bath of chloride of calcium the burning could be dispensed with, and a series of experiments made in 1861 by Professor Frankland showed most conclusively that Ransome's patent concrete stone, when only a fortnight old, was equal to the best of the natural stones. Soon after Mr. Ransome's first patent, in 1847, a Mr. Buckwell obtained a patent for "granitic breccia stone," which, I believe, was used in 1851 in the Hyde Park Exhibition.

This was essentially a concrete, as it consisted of fragments of suitable stone, broken into small pieces and mixed with cement, with a small quantity of water, not more than enough to bring it to a damp state. This was put into a mould and powerfully compressed with a percussive action, and more of the materials added until the requisite thickness of block was obtained. The block was thus rendered very dense and compact, and this artificial stone was used for water tanks, than which no severer test can be applied of the qualities of an artificial stone. At the present day the artificial stone which is most used is the well-known Victoria stone, the patent for which was originally obtained by a Mr. Highton. The aggregate of which this stone is composed is ground Leicestershire syenite, a species of granite containing hornblende instead of mica, and lacking quartz, which is thoroughly washed, so that no earthy particles remain, and an ingenious machine has been patented for doing the washing business.

After being washed, the aggregate is carefully mixed with a certain quantity of Portland cement of the very best quality, and is placed in iron-lined wooden moulds, which are filled to the top, but no pressure is applied; after the concrete is set it is taken from the moulds and placed in a bath of liquid silicate of soda, and after ten days' immersion the block becomes so thoroughly impregnated with silica that nothing but the strongest acids will free it again. The stone thus becomes intensely hard, and quite impervious to weather action—in fact, its hardness increases with time. This property makes it invaluable for copings, sills, paving, etc., and it has another advantage over ordinary stone—that heads and sills can be cast in as long lengths as can be desired, thus avoiding joints. It is used also for sinks and other such purposes. The silicate used in the manufacture of this stone is obtained from the Farnham stone found under the Surrey chalk beds, and is boiled in coppers with caustic soda. One of the most enterprising modern pioneers in concrete building was the late Mr. W. H. Lascelles, of Bunhill row, who was a most sanguine believer in the future of this material.

Mr. Lascelles actually built cottages which were not only habitable, but comfortable, the walls of which were only 1½ in. thick, formed of slabs of cement concrete, the outer side cast in imitation of brick or tiles, and the inner side left rough for plastering. These very thin walls appear to have kept out the weather perfectly, but moisture condensed on the inner face, so Mr. Lascelles improved upon his original idea by having a double casing of slabs with a cavity between. He also formed floors of concrete, window-frames, and roofs; but the latter did not turn out very successful, as there was always a certain amount of shrinkage. This system did away almost entirely with the use of wood, and consequently the houses so built were as near being fireproof as they could be got. Mr. Lascelles' concrete is composed of four parts of powdered coke and one part of cement mixed together in a mill, with a small quantity of water, and cast in moulds without pressure, and by mixing metallic oxides in the form of powder with the cement, the concrete is colored any desired tint.

Very excellent specimens of mullioned windows, chimney caps, head and sills, strings, copings, panels, and over mantels are made in this material, and are largely used as a substitute for stone, and it is much cheaper than stone; but I am bound to say I have seen cases where the color has not been retained as it ought to be, and I am informed that this is caused by the workmen giving the slabs a top dressing of colored cement after they come out of the moulds. Of course this should never be done, as the color should really penetrate some depth into the mass of concrete. For standing a London damp and smoky atmosphere there can be no doubt of the great superiority of this concrete to almost any natural stone. Messrs. Lascelles also make a very good wall on what is termed Potter's patent. In this, a casing of concrete slabs, of which one face is fair, is put up, and ordinary concrete filled in between, just as in the way I described in the wooden framework; but as the slabs are intended to remain, they are formed with a key, so that when the core of concrete sets, it is quite impossible for the skin of slabs to move. Among the numerous purposes for which this material is used may be mentioned silos, water-tanks, sewer-pipes, columns, etc.

It would occupy too much time were I to attempt a description of all the methods of concrete construction that have been invented, such as Tall's, Drake's, and others; but the most recent of them—the system patented by Messrs. West—has various novel features about it which deserve attention. This, like Potter's system, is a slab construction filled in with rough concrete; but the form of the slabs is ingeniously arranged, so that no temporary tie or external support is required during building. The slab itself is made of concrete cast in a mould, so that on one side is a finished face, plain or ornamental, as the case may be, and on the other a sunk panel about half the thickness of the slab itself, with its edges undercut, so that when in position and the mass of semi-liquid is concrete poured in, the slabs are securely keyed to the general mass. Dovetail mortise-holes are also formed in the top and bottom edges of the slabs, in order that when laid they may be kept in their proper place by simply pouring into these holes some quick-setting cement. There is also

a narrow groove along the edges of the slab, which, when filled with cement, acts as a joggle joint, keeping the slabs together. An inner and outer casing of slabs is thus set up, and the plastic concrete poured in, filling up the sunk panels and making with the slabs a perfectly solid wall.

For openings, jambs are moulded having recesses or dovetailed holes, into which the fluid concrete may penetrate, so that they can be thus keyed to the general mass of the wall. The slabs are made either rectangular or hexagonal on plan, and as they are all cast in a mould, there is, of course, not the slightest difficulty in arranging for circular work, splayed angles, or anything of that kind. There has always been considerable difficulty in arranging for moulded or enriched string courses or projections with concrete, and this difficulty is proposed to be overcome by casting the moulding first and then applying it to the slabs while they are in a plastic state, the moulding thus becoming part of the slab, which is then fixed in the required position. The moulds for casting these slabs are made of metal and lined with India rubber. Similar slabs can be moulded with curves for constructing domes, and ceiling slabs can be made with rebates, so that they can be supported on iron joists or girders. This system of concrete building is certainly the most scientific and the most complete that has yet been invented, and I have no doubt whatever that a building thus erected would be perfectly dry and very strong; but I am somewhat disposed to think that the system is a little too complicated to be cheap, as the labor required for properly setting the slabs in place and cementing them together would nearly equal that required for a stone wall.

The inventors have, however, shown so much skill in maturing their design and providing for all difficulties, that it is quite possible they may soon be able to point to actual works carried out on their principle, and to give accurate details of cost, which I am not able to do now. A very ingenious traveling scaffold and concrete elevator have also been invented by Messrs. West, which obviate the necessity of erecting a scaffold all round the work, and require no putlog holes to be left; and undoubtedly some such arrangement as this has been a great desideratum as an auxiliary to concrete construction. There can be little doubt that this system of concrete building would be of most material use in the construction of farm buildings, cottages, etc., in country districts far removed from railways, as the slabs are light and portable, and the material for the filling can generally be obtained on the spot. For paving purposes concrete is, of course, excellently adapted; but it is very difficult to get ordinary workmen to lay a concrete floor properly. What they like is to lay the concrete and let it get hard, and then finish off the top with a thin coating of neat cement.

This looks very well when it is first done; but sooner or later the thin coating begins to flake off or crack, and looks very bad. The proper way is to break up the materials of the concrete to a small size, and then, in laying it, to trowel it off at the top as smooth as possible, so that it is all one mass and no layers exist. Portland cement should always be used, and if ordinary care be taken, there is no reason why a laborer should not lay an excellent concrete floor. There are many patents for concrete paving, of which I may mention Drake's granitic concrete and Macleod's granite, which has been largely used in the North of England for warehouses, stables, etc. It is not cast in blocks, but laid *in situ*, and it can be made to take somewhat of a polish if desired. This forms an extremely hard, impervious pavement, and it looks very well; but I really believe the whole secret of the excellence of these patent systems of paving lies in the careful manipulation of the materials and the sparing use of water. I may state here that for engine beds concrete is, in many respects, far superior to stone, as it is not liable to chip and crack, and it is very much less expensive. I now come to the last division of my subject, and that is the use of concrete for vaults and in fireproof construction.

#### CONCRETE BUILDINGS.

Every one is acquainted with the fact that an ordinary arch exerts a thrust which has to be counteracted, or it would soon push out its abutments. A concrete arch, however, after it has set, forms a complete, homogeneous mass, and exerts only a dead weight on its supports. The Romans were aware of this, and constructed the boldest and most extensive vaults of concrete—as in the Baths of Caracalla, and the House of the Vestals, lately excavated. They were careful, moreover, to make the concrete used for these purposes of lighter materials than that employed for walls or pavements. The great dome of the Pantheon was constructed entirely of concrete of varying thickness, and the walls supporting this enormous mass were twenty feet thick. In the House of the Vestals the whole of one of the upper floors, about twenty feet span, consisted entirely of a great slab of concrete fourteen inches thick, merely supported by corbels projecting from the walls, and in the Baths of Caracalla there are still extensive remains of large concrete vaults. We, in this country, have not yet obtained satisfactory evidence of the safe span and thickness of a concrete vault; but the material is very largely used to form small arches in fireproof floors. It is quite impossible to treat the very important question of fireproof buildings fully at the end of a lecture—the subject demands a whole evening to itself; but whatever system of fireproofing be adopted, concrete will prove to be the most important element in it. Whereas the opinion used to be held that iron girders and columns as supports to a building were sufficient to make it fireproof, we have been taught by sad and costly experience that this is very far indeed from being the case.

In the United States and in France they are much more particular than we are in this matter, and, in the former country, it is laid down as an incontrovertible maxim that "no building can be fireproof unless all constructional ironwork be protected," and no better material can be found as a protection than concrete. Stone is utterly valueless in this respect, as it will crack when heated, and give way without any warning whatever. Fox and Barrett's system consists in filling in concrete between wrought iron joists, the concrete being supported on fillets of wood placed about ½ in. apart and resting on the bottom flanges

of the iron joists, the under side of the wood fillets being plastered. Either the concrete is carried up the requisite height and forms the floor, or, if a wooden floor is required, small joists are cut to a dovetail section and embedded in the concrete, and the floor boards nailed to them. Dennett's system is almost exclusively a concrete construction, consisting of concrete, arches supported next the walls on projecting courses, and by hollow iron joists at intermediate points. In this system gypsum is mixed with the Portland cement to form the matrix, as experiments have shown that this substance can be heated to whiteness and then suddenly cooled without being injuriously affected.

In Hornblower's system the iron girders are surrounded by cement, and inclosed in a fireclay casing, supporting fireclay arches. Even concrete arches supported on triangular shaped wooden joists form a floor which is very largely fireproof. If iron columns are used, a temporary wooden casing should be erected round them, leaving a space of about 2 in., which should be entirely filled up with Portland cement concrete, and if a fine face be desired this can easily be obtained by cementing the concrete. Messrs. Lindsay have patented two systems, which comprise the use of steel decking, as it is called, and concrete arches, the girders being entirely covered with concrete, both at top and bottom. The concrete used by this firm is very light; it is called pumice concrete, and is composed of washed coke breeze and sand mixed dry and Portland cement of the very best quality. It is, of course, self-evident that if you get sufficient adhesiveness and transverse strength, the lighter the mass of concrete is for upper floors or vaults, the better, as so much less weight is thrown upon the supporting walls or columns. The steel girders for this kind of floor are of peculiar shape, and the system is a novel one, and appears to me likely to prove of great value for buildings of considerable size, where girders are a necessity for supporting upper floors.

These girders may be described as truncated equilateral triangles, set alternately on their bases and their truncated vertices, and riveted together at their sides, forming a series of hollows and elevations. They are constructed of rolled steel about ½ in. in thickness, and their depth need not be much more than half that required for an iron girder. When the weights required to be supported are not very heavy, a combination of these steel girders with ordinary rolled joists can be adopted. The iron joists can be placed about 14 ft. apart, and from the steel skewbacks riveted to the joists, arches of concrete can be turned on centering. There is a possibility with concrete floors that would withstand any ordinary strain, that the sudden fall of anything like a huge iron safe might break through the floor; and in order to avoid any risk of this kind, Mr. Lindsay runs steel wires through the joists the whole length of the floor before the concrete is filled in. These are about 18 in. apart, and are strong enough to hold up any exceptional weight that may by accident come upon the floor. In addition these steel wires form a sort of nucleus round which the concrete sets. The total weight, girders and all, of these latter floors is considerably less than that of any other system, and they are extraordinarily strong. I have now endeavored to bring before you some of the purposes for which this common material, concrete, is adapted. Its use is extending daily, and in that extended use lies a danger which it behooves us all to guard against; whether you are employing it for floors, for pavings, for walls, for vaults, for architectural enrichments, or what not, it cannot be too strongly insisted upon that scamping of every kind must be avoided, that the quality of the Portland cement used in its manufacture must be of the very best, and that no labor in manipulation must be spared, for if inferior materials be used, or carelessness in working, the results are sure to be disastrous, and grave discredit will be thrown upon a most useful building material.

The subject is a sternly practical one, and it has been impossible to illustrate it by elaborate and beautiful drawings; but, at least, we can learn one lesson from it, and that is, the great, the incalculable value of thoroughness in all the work which we have to undertake. As I commenced by referring to the Roman builders, so I would conclude by pointing to them again as a model for us. Depend upon it, when they were building the walls of those edifices which are still the wonder of the world, they gave no thought to what posterity would think of them; they simply did their work in the best way they knew of, and spared no pains to make it good; and if we imitate them in this, we shall all, whether architect, builder, or artisan, have the satisfaction of feeling that we have done some bit of good work. And although it is not given to us all to be great artists and to "win the world" with noble buildings, we can at least put our whole heart into everything we undertake, and display what has been described as the truest genius—an infinite capacity for taking pains.

#### TESTS OF VEHICLE WHEELS.

A NUMBER of wheel manufacturers recently subscribed to a fund for carrying out an elaborate series of tests to determine the relative strength of the various modes of constructing carriage and wagon wheels. Mr. H. M. Du Bois was chosen to carry out the experiments, the U. S. Standard testing machine of Riehle Bros., in Philadelphia, being used for the purpose. A cast-iron disk, four feet in diameter, and having a raised edge six inches high, was placed in position on top of the testing machine, and upon this bed-plate the wheels were placed, face downward. The pulling pressure was attached to a bolt passing through the hub. The various specimens were full-sized wheels.

In vehicle wheels, two requirements are necessary—resistance to pressure and elasticity. It is not enough that a wheel should resist a certain amount of weight applied through the axle, but it must return to its normal condition, ready to resist again. The point of this resistance without change is the one sought to be established by these tests. It was found that the power to return to normal condition under pressure is in proportion to the distance between the rim and the hub. Consequently, any marked departure from the proportions of the old wooden hub is not good practice. Though it is a great desideratum to gain strength at the hub, it must be accomplished without loss of elasticity, or the resulting wheel will be but an inferior article.

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## IMPROVED BLEACHING PROCESS.

By a combination of improved processes, partly mechanical and partly chemical, Mr. W. Mather, M.P., of the Salford Ironworks, Manchester, and Mr. J. B. Thompson, of New-cross, Kent, have introduced what may be fairly described as a new method of bleaching textile fabrics. This new system is termed the Mather-Thompson bleaching process, and the successful working of the several operations for completing the process we had recently an opportunity of seeing practically demonstrated at the works of Messrs. Ainsworth, of Halliwell, near Bolton. The main features of the changes which have been introduced are that in the first stages of the bleaching, after the usual cleansing from size and loose impurities, the entire alkali treatment is completed in one operation, in Mather's patent steaming keir, and the use of lime and soda ash in successive long-continued boilings is entirely dispensed with, while the subsequent whitening of the cloth is effected instantaneously in passing through the Mather-Thompson continuous chemicking machine. The appliances for carrying out the Mather-Thompson process of bleaching are shown in our illustrations herewith. Before, however, entering into a detailed description of these appliances, the special features of the Mather-Thompson process will perhaps be better understood if we give a brief outline of the ordinary practice of bleaching, with which the new process is to be contrasted. The bleaching of textile fabrics consists in the main of two operations—first, the treatment with alkaline solutions; and, secondly, the whitening process, the agent employed for which purpose is almost exclusively a solution of bleaching powder. These two operations under the ordinary system involve, however, eight different treatments with reagents, with eight attendant washings, and the whole process will be most readily set forth in tabulated form as follows:

Alkali.	Bleach.	Acid.	Machine Washes.
(1) Lime stew.		(2) Sour.	(1) Wash.
(3) Gray bowk. (Soda ash.)		(5) Sour.	(2) Wash.
	(4) I. Chemic.		(3) Wash.
(6) White bowk.		(7) Sour.	(4) Wash.
	(7) II. Chemic.		(5) Wash.
	(8) Sour.		(6) Wash.
			(7) Wash.
			(8) Wash.

In going through the above process, the cloth is actually in work forty hours. By the Mather-Thompson system, the processes are practically reduced to three, as shown in the following table, 3 and 2a being merged into a single process by means of a continuous machine, and the period during which the cloth is actually in work is reduced to twelve hours:

Alkali.	Bleach.	Acid.	Machine Washes.
(1) Saturate. (Steam.)	(chemic).		
(2) Continuous (chemic) machine (or keir if for yarn, etc.)			
		(2a) Machine or pit sour.	
		(3) Wash up for finishing.	

The first operation of the Mather-Thompson process, and which embraces the patented improvements introduced by Mr. W. Mather, is the Mather's patent steaming keir, shown in Figs. 1 and 2, which represents respectively the method of working cloth in a rope state and in full width state. The cloth or yarn to be bleached is first passed through a hot solution of caustic soda. It is then deposited in galvanized iron open framework wagons, each holding about a ton in weight, and these are run upon rails into what is termed a "steaming keir." This steaming keir is an apparatus which completes in one operation the full alkali treatment of the cloth in bleaching. It replaces the ordinary keirs, whether of high or low pressure, and enables all boiling in alkali to be dispensed with for every kind of cloth or textile material. By means of this apparatus, all descriptions of cloth or yarn can in a space of from five to eight hours be thoroughly

"bottomed" and made ready for the chemic and sour treatment in bleaching. The entrance door to the steaming keir is raised and lowered by steam or water pressure, and the joint is made tight by a self-acting arrangement without the use of bolts. The loaded wagon having been inclosed in the keir, the soda held in solution in the cloth does its work with the aid of steam under a pressure of not more than 4 lb. to the square inch, a light sprinkling of a weak solution of caustic soda being kept up from the top for the purpose of preserving the cloth moist and preventing damage from dry heat. Before being removed from the keir the cloth is thoroughly washed in hot water by a circulating pump, and as one set of wagons is taken out, another set filled with cloth immediately takes their place, so that there is no pause throughout the day in the use of the keir. This one operation, as already stated, completes the entire alkali treatment, and lime is wholly dispensed with, as well as the boiling in keirs. The cloth is then passed on to the Mather-Thompson continuous chemicking apparatus, shown in Fig. 3, the main feature of which is Mr. Thompson's invention for the direct application of carbonic acid gas to cloth previously saturated with a

ers have been compelled to get a portion of their supply by pumping from the water-bearing strata below the surface. With, therefore, the limited sources of water supply, a discovery which so greatly minimizes the quantity required is of incalculable value. It is even thought that, with the present charges for bleaching, it might be found possible to establish works in Manchester or other manufacturing centers, and, with the small quantity of water required, obtain this from the ordinary water supplies, which will indeed be something like a revolution in the bleaching industry.

In closing our description of the Mather-Thompson process—which we have dealt with as a combination of practically two classes of improvements, by the alkali treatment in the "Mather steaming keir," and "Mather-Thompson treatment" in the chemicking process—we may add that the alkali treatment is just as applicable for use in connection with the ordinary "chemic and acid" method of bleaching as with new "continuous chemicking process." It will therefore be available for calico printers and dyers as well as for bleachers who do not care to make the necessary alterations for adopting the latter machine; and it is, indeed, in the "steaming keir" and the caustic soda

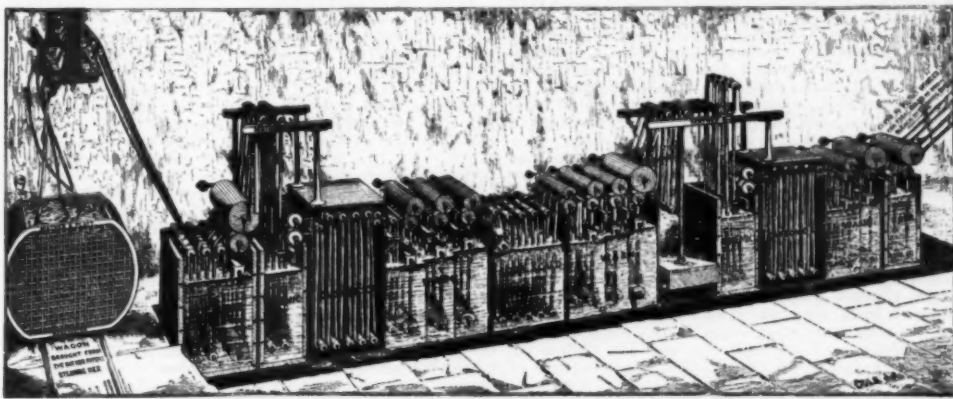


FIG. 3.—THE MATHER-THOMPSON CONTINUOUS CHEMICKING MACHINE.

solution of ordinary bleaching powder, the result of this application being the immediate oxidation of the coloring matter of the fiber, and its consequent instantaneous whitening. Our illustration so clearly shows the operation of the continuous chemicking apparatus through the order of treatment—(1) saturation with weak chemic, squeeze and passage to gas chamber; (2) wash (running); (3) soda scald; (4) wash; (5) repetition of 1, but with weaker chemic; (6) wash; and (7) souring—that further detailed description is scarcely required, and we need only add that as the cloth travels through the continuous machine in four strands in the rope state or in the open state at the rate of 60 to 80 yards per minute, the actual chemicking process is practically completed in a period of not more than two or three minutes. The next and final operation—that of souring—which is as essential to this as to every other system of bleaching, can either be included in the continuous process or made a distinct operation, as may be the most suitable to meet requirements.

The advantages which are secured by this new method of treatment are that only one-fifth of the water is required for washing, as compared with the ordinary system, and a saving of about one-third the chemicals is effected; there is also a great saving of time and fuel, while there is not one-half the wear and tear. In addition to these direct advantages, the use of lime being wholly unnecessary, the cloth is less liable to the usual stains in bleaching, while it undergoes considerably less handling during the process.

Out of all the economy of time, labor, and material which has been effected, the great saving in the quantity of water required by the new system may, however, be regarded as perhaps one of the most important features of the Mather-Thompson process. Long since all the suitable and available streams for bleaching have been appropriated; and in some instances bleach-

treatment, which is the really novel and striking feature of the new process, that the greater part of the saving is effected.—*Textile Manufacturer.*

## PHOSPHORESCENCE OF MARINE ANIMALS.

THE address in Section D, biology, of the British Association was delivered by Professor W. C. McIntosh, M.D., of St. Andrews, who selected for his subject the "Phosphorescence of marine animals." A phenomenon so striking as the emission of light by marine organisms could not fail to have attracted notice from very early times, both in the case of navigators and those who gave their attention in a more systematic manner to the study of nature. Accordingly, we find that the literature of the subject is both varied and extensive—so much so, indeed, that it is impossible on the present occasion to give more than a very brief outline of its leading features. Though it is in the warmer seas of the globe that phosphorescence is observed in its most remarkable forms—as, for instance, the sheets of white light caused by Noctiluca and the vividly luminous bars of Pyrosoma—yet it is a feature which the British zoologist need not leave his native waters to see both in beauty and perfection.

Many luminous animals occur between tide-marks, and even the stunted seaweeds near the line of high-water everywhere sparkle with a multitude of brilliant points. As a ship or boat passes through the calm surface of the sea in summer and autumn, the wavelets gleam with phosphorescent points, or are crested with phosphorescent points, or are crested with light; while the observer, leaning over the stern, can watch the long trail of luminous water behind the ship from the brightly sparkling and seething mass at the screw to the faint glow in the distance. On the southern and western shores, again, every stroke of the oar causes a luminous eddy, and some of the smaller forms are lift-

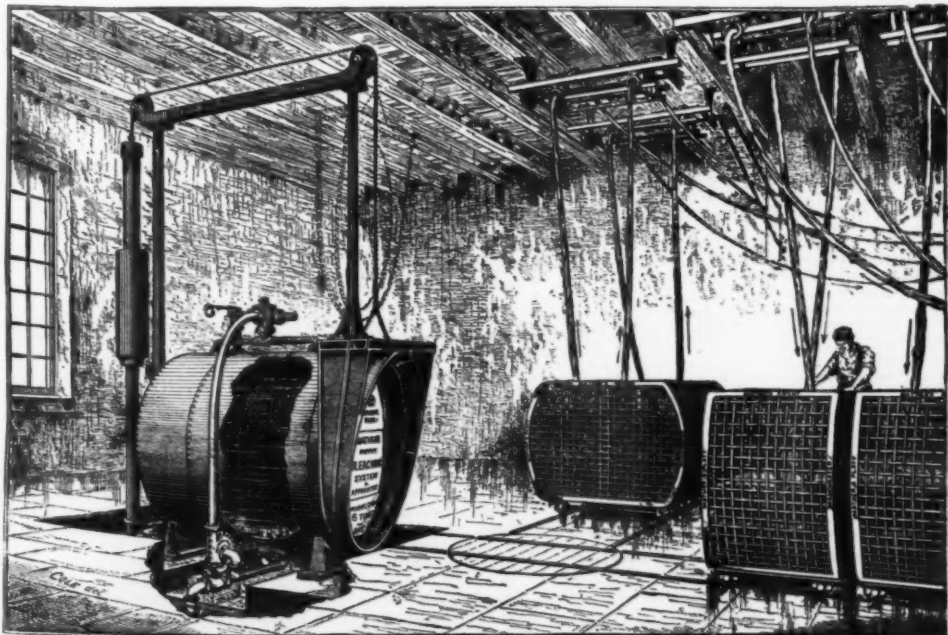


FIG. 1.—MATHER'S STEAMING KEIR.—TREATING CLOTH IN THE ROPE STATE.

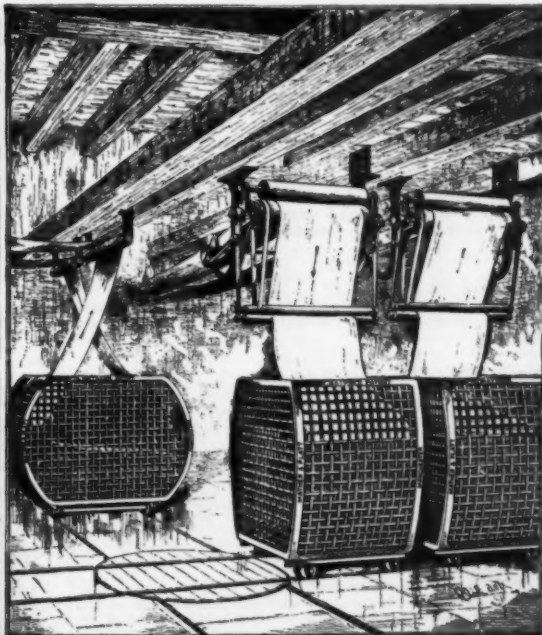


FIG. 2.—TREATING CLOTH IN THE FULL WIDTH STATE.

ed by the blade and scintillate brightly as they roll into the water. The dredge and trawl likewise produce, both in the shallower and deeper parts of our seas, many luminous types of great interest and beauty.

He glanced, in the first instance, at the various groups of marine animals which possess the property of phosphorescence, and continued: It is found that this feature is possessed by certain members of the Protozoa, and by the following groups of the Metazoa, viz., ctenophores, echinoderms, worms, rotifers, crustaceans, molluscs, mollusks, and fishes. In foreign seas many brightly luminous specimens are met with. Thus Professor A. Agassiz describes *Mnemiopsis leidyi* as "exceedingly phosphorescent, and when passing through shoals of these Medusae, varying in size from a pin's head to several inches in length, the whole water becomes so brilliantly luminous that an oar dipped in the water up to the handle can plainly be seen on dark nights by the light so produced; the seat of the phosphorescence is confined to the locomotive rows, and so exceedingly sensitive are they that the slightest shock is sufficient to make them plainly visible by the light emitted from the eight phosphorescent ambulacra."

The same author mentions that *Leueureia* has a very peculiar bluish light of an exceedingly pale steel color, but very intense. Giglioli, again, found that the beautiful ribbon-like *Cestus* shone with a reddish-yellow light, but in *Eucharis* the latter was intensely blue. In the Chaetopteridae the phosphorescence is remarkably beautiful, bright flashes being emitted from the posterior feet. Marine phosphorescence has some of its most striking examples among the Tunicates. One of the best known instances is that of *Pyrosoma*, the light from which has been so graphically described by M. Péron, Professor Huxley, and other naturalists who have had an opportunity of observing it. It proceeds in each member of the compound organism from two small patches of cells at the base of each inhalant tube.

Phosphorescence in living fishes appears to have been accurately observed within a comparatively recent date, though the luminosity of dead fishes has been known from very early times, and has been the subject of many interesting experiments, such as those of Robert Boyle on dead whiting, and Dr. Hulse on herrings. I do not mean to say that the literature of the so-called phosphorescent fishes is scanty, for it extends from the days of Aristotle and Pliny to modern times, but that the writers have had little reliable evidence in regard to living fishes to bring forward. Thus, of upward of fifty fishes entered by Ehrenberg in his list, it is hard to say that one is really luminous during life. In many cases it is probable that the supposed phosphorescence of large forms, such as swordfishes and sharks, has arisen from the presence of multitudes of minute phosphorescent animals in the water, just as the herring causes a gleam when it darts from the side of a ship.

Professor Moseley, for instance, observed in the Challenger that when large fishes, porpoises, and penguins dashed through phosphorescent water it was brilliantly lit up, and their track marked by a trail of light. The same feature is observed in hooked fishes, and it is known that fishermen are doubtful of success when the sea is very phosphorescent, for the presence of the net in the water excites the luminosity and scares the herring. One of the most striking instances of phosphorescence in living fishes is that of the luminous shark (*Squalus fulgens*), found by Dr. Bennett. This is a small, dark-colored shark, which was captured on two or three occasions at the surface of the sea. It emitted without irritation a vivid greenish luminosity as it swam about at night, and it shone for some hours after death. The phosphorescence appears to be due to a peculiar secretion of the skin. The eyes of the shark were more prominent than usual in such forms.

A survey of the life-histories of the several phosphorescent groups affords at present no reliable data for the foundation of a theory as to the functions of luminosity, especially in relation to food. No phosphorescent form is more generally devoured by fishes or other animals than that which is not; and, on the other hand, the possessor of luminosity, if otherwise palatable, does not seem to escape capture. An examination of the stomachs of fishes makes this clear, except, perhaps, in the case of the herring, which, however, is chiefly a surface fish. Further, it is not evident that such animals are luminous at all times, for it is only under stimulation that many exhibit the phenomenon.

DIETETIC DELUSIONS: THEIR DELETERIOUS EFFECTS, AND THEIR RECTIFICATION.\*

By R. M. HODGES, M.D.

THE amount of food required by a healthy adult will surprise most persons, even those who are good feeders. While this varies with the work performed, the heat or cold of the weather, and the condition and quality of the food taken, it has been estimated that, in the case of a man in health and of average size, the total daily ration should weigh 8 pounds 13 ounces 128 grains, of which 1 pound 4 ounces 345 grains consist of dry food substance, the remaining 5½ pounds being water.†

\* Read before the Boston Society for Medical Improvement, June 9, 1884. From the *Boston Medical and Surgical Journal*.

† Under ordinary circumstances a daily ration should contain something like the following proportions and quantities of its main ingredients:

Water.....	5 lb. 8 oz. 320 grs.
Albuminoids, or flesh formers.....	0 lb. 4 oz. 110 grs.
Starch, sugar, etc.....	0 lb. 11 oz. 178 grs.
Fat.....	0 lb. 3 oz. 337 grs.
Common salt.....	0 lb. 0 oz. 325 grs.
Phosphates, potash, salts, etc.....	0 lb. 0 oz. 170 grs.

This might be furnished by a mixed diet of the following foods:

Bread.....	19 oz.
Butter.....	1 oz.
Milk.....	4 oz.
Bacon.....	2 oz.
Potatoes.....	8 oz.
Cabbage.....	6 oz.
Cheese.....	3½ oz.
Sugar.....	1 oz.
Salt.....	¾ oz.
Water alone and in tea, coffee, beer, etc.....	65½ oz.

Altogether these quantities will contain about 1 lb. 5½ oz. of dry substance, though they weigh in all 8 lb. 14½ oz.

It will be seen that the weight of this allotment exceeds by one ounce—when the solid matter contained in beverage is omitted—that of the analytic table which precedes it. This excess is mainly owing to the fact that in all articles of food actually used there are small quantities of matters (cellulose, etc.) which cannot be reckoned as having a real feeding value.—A. H. Church, "Food: Some Account of its Sources, Constituents, and Uses," London, 1880, p. 49, et seq.

Authorities on the subject of diet say that nitrogen is the most essential of all foods, and that a certain amount—about 316 grains—should be taken daily by an adult man. If the minimum quantity of nitrogen (which, for the sake of argument, may be put as low as 250 grains) be not consumed, the various functions of the body languish, and a degree of weakness is induced, with greater or less rapidity, according as the quantity falls much or little below 250 grains per diem. But let the consumption drop to an average of only 138 grains, which is the smallest amount necessary for the bare maintenance of life, and in a year or two (not at once, for every body contains a store of nitrogen) important modifications of the nutritive processes, with distinct predispositions to disease, will inevitably be established.\*

These results of experimental investigation have a practical significance. They find expression in the fact that a failure to consume all the essential elements of full rations, whether nitrogenous or non-nitrogenous, will sooner or later, as in the disastrous Irish and Lancashire famines, give rise to a train of symptoms which have been justly denominated those of "chronic starvation."

From the small knowledge of the value of food possessed by individuals as well as the public, a diminution in its adequate supply easily escapes attention; loss of appetite is looked upon with indifference, and the first steps are inadvertently taken toward a condition which is as full of meaning in the case of a single person as when a whole community are its subjects. The absence or the keenness of appetite affords no indication of the amount of food which the stomach will digest and the body assimilate or an individual be benefited by swallowing.

The body requires not only to be fed, but filled; and the object of eating is as often to bring up past arrears as to supply present demands. Quality of food, with all the heat and force it may contain, will not make up for quantity, which is required for constructive and reparative purposes. The constant waste of flesh and blood can only be compensated for by an equivalent assimilation of actual materials. Yet, in spite of this self-evident proposition, a large proportion of the better educated classes of the community readily deceive themselves and mislead others in regard to the amount of food necessary for their welfare and nutrition.

From a practice, often beginning in infancy with the common maternal prejudice against giving solid food at a sufficiently early period and in adequate amount, persisted in through childhood from an erroneous idea that "meat once a day" is an ample supply of animal food, still continued during adolescence, especially in the case of girls, under the conceit that eating heartily, or "between meals," is neither wholesome nor ladylike, a habit of going without enough sustenance is finally established in adult life which is further perpetuated and confirmed by a great variety of influences. Among the more common may be mentioned personal temperament, disturbed mental conditions, languid indoor life, fatigue and exhaustion, theoretical dietetic prejudices, fastidiousness as to eatables, unwise distribution of meals, insufficient variety of food, too rigid domestic economy, and, pre-eminently, the revived fashion of tight lacing. These, and a multitude of similar agencies, apart from pathological derangements, are well recognized causes of deficient bodily nourishment and prolific sources of disturbed health, revealing themselves in deficient weight, "weakness," anemia, feeble circulation, neuralgia, cough and throat trouble, constipation, headache, backache, nausea, and a variety of phenomena, unconnected with sensible organic alterations, but characterized by neurotic and functional symptoms easily magnified by the patient and overrated by the physician.

The consequences of an insufficient dietary are most frequently exemplified in young people, of both sexes, growing school children, boys fitting for college, debutantes in society, young mothers of families, seamstresses, shop girls, etc.; and, although they also appear at other periods of life, and under other circumstances than those which have been enumerated, it is during the years of adolescence that the utilization of feeding has its supreme value, and its prophylactic and curative effects, as a therapeutic method, are most easily obtained. Sir Andrew Clark, Mr. Grailly Hewett, Mr. Clifford Allbutt, and others, who have described the ailments which follow inadequate alimentation, have especially urged the necessity for greater attention to the question of diet in the bringing up of families.

The underfed constitute so considerable a class that a large part of medical practice is devoted to attempts at satisfying their importunate demands for "something which shall make them feel better." To attack with drugs symptoms which are daily regenerated by starvation is labor in vain, so long as that condition is permitted to exist. But if the famished tissues of those who say they are not sick, and there is nothing the matter with them, only that they "do not feel well," and "cannot eat," be permeated with the fat which is so often loathed in food—if veins be filled with a more

bounteous supply of blood, and if out-door air be made attainable without the expenditure of an already slender supply of strength—their bodily functions will take on renewed vigor and be reanimated from better life-giving resources, force will be stored up, energy will be developed, and innumerable discomforts evicted. The futile use of iron, quinine, bitters, elixirs, and other so-called "tonics," either when self-prescribed or methodically directed by physicians, and the insuccess of medicines, as a rule, to relieve the wearisome complaints daily listened to from persons whose mode of living is an injustice to themselves, do not always serve as a reminder that suitable nutriment, in some form or other, is the only real "tonic," and that its methodical consumption can alone relieve the protean afflictions of many, if not most, of these querulous supplicants. To say to them in a vague and general way that a nourishing diet should be taken, and that anxiety and overwork are to be avoided, is to give weak advice. The most rigid and literal obedience to fixed and precise rules in regard to the quantity and character of their food and the times of taking it—in fact, the carrying out of a process of "stuffing," practiced at short intervals of time, without regard to appetite and pushed to the stomach's maximum capacity of digestion—is necessary to extricate them from their deplorable situation.

It is not my purpose to describe in detail the ailments and functional irregularities which are successfully dealt with by dietary treatment, but to make some criticisms on prevalent habits of eating, to offer certain practical suggestions in regard to methods of improving them, and a few homely remarks on the extent to which feeding beyond inclination may be advantageously pushed, and the kinds of food, and its adjuncts, by which its effective adoption may be promoted.

The theoretical standard of a full ration has been given. The conventional standard, however, is an unsettled one. The statement that a person eats as much as other members of his or her family may mean a great deal or nothing, for there are large and small eaters both by habit as well as by example, and there can be no criterion of the amount proper to be eaten under given circumstances except that which is determined by a physician's judgment. This amount, as has been said, should not only be specified exactly, but its consumption insured, and nothing but precise and positive evidence accepted in regard to the fulfillment of the specifications given.

To secure a constant and sufficient conversion of food material by those who are or have been insufficiently fed, vigilant supervision is often requisite. The personal influence which accomplishes this is a variable possession. Some persons can win obedience where others might capitulate, and will exhibit a persistency in carrying out their suggestions which makes successful feeding a certainty when more lenient and compromising tactics would fail. Enfeebled subjects, especially women, often feel a great satisfaction in being controlled, and in being led, lifted, pushed, by a strong will. With such individuals resolute oversight tells. That which they say in regard to eating they "cannot do" they are made to do. When they think they "do their best" they are compelled to do more and better, and an assertion that they will "try" to eat is counterbalanced by a determination that they shall succeed. No symptom of the feebleness which results from being underfed is more characteristic of the condition than the almost invariable obstinacy of its subjects to accept advice which suggests an increase in their consumption of nutriment, and no steps in securing a mutual understanding between physician and patient are so difficult as those directed to overcoming the dogged resolution and pertinacity which are manifested in this respect.

As a stomach may become over-distended and permanently dilated by long gluttony or by the accumulated ingesta which a slow and feeble peristalsis refuses to move on, so may it also become contracted from the habitual want of sufficient victualing, sometimes to such a degree that the introduction of enough food can only be accomplished after the gradual dilatation of its receptacle. This may be effected by increasing the frequency of meals. The custom, common in this country, of leaving a long interval between them is the reverse of that desirable for those who require extra feeding. The ordinary European arrangement adopts a system which is worthy of imitation, a "little and often" being the motto of the eater. It is useless to attempt too much at one time. The stomach conforms slowly, and rebels at a certain limit, but a brief respite and a short intermission put it in a less antagonistic attitude. If, for the reasons given, or from mere disinclination, two meals have been all which the subject under treatment declares can be "got down," as is often the case, then three must be taken or the time between successive feedings shortened to two hours, according to the aggregate amount of nourishment intended to be given and the readiness with which its forced consumption is effected. It is an advantage, therefore, that certain periods of the day, not precisely fixed, but approximate, should be established as meal times. For instance, before rising, at the usual breakfast hour, in the middle of the forenoon, at the accustomed luncheon, in the middle of the afternoon, at the regular dinner, and on going to bed.

It is a common impression that to take food immediately before going to bed and to sleep is unwise. Such a suggestion is answered by a reminder that the instinct of animals prompts them to sleep as soon as they have eaten; and in summer an after-dinner nap, especially when that meal is taken at midday, is a luxury indulged in by many. Neither darkness nor season of the year alters the conditions. If the ordinary hour of the evening meal is six or seven o'clock, and of the first morning meal seven or eight o'clock, an interval of twelve hours, or more, elapses without food, and for persons whose nutrition is at fault this is altogether too long a period for fasting. That such an interval without food is permitted explains many a restless night, and much of the head and back ache, and the languid, half-rested condition on rising, which is accompanied by no appetite for breakfast. This meal itself often dissipates these sensations. It is, therefore, desirable, if not essential, when nutriment is to be crowded, that the last thing before going to bed should be the taking of food. Sleeplessness is often caused by starvation, and a tumbler of milk, if drunk in the middle of the night, will often put people

\* Parkes, "Practical Hygiene," p. 173, et seq. Gr. Hewett, *British Medical Journal*, August 4, 1883, p. 225.

† The manufacturers of cellulose and paper pulp propose, by an advancement of scientific cookery, to resolve nut shells, wood shavings, and sawdust into wholesome and digestible food. They remind us that a pear, which, when full grown in autumn, is little better than a lump of acidulated wood, with careful storing for two or three months becomes, by nature's unaided cookery, the most delicate and juicy pulp which can be tasted or imagined; and that cotton and linen rags have been converted into sugar artificially in the laboratory of the chemist.—*Paper Maker's Monthly Journal*, February 15, 1884, p. 49.

At the existing (1884) International Health Exhibition, London, the "Vegetarian Society" are furnishing a sixpenny dinner to four or five hundred people daily. From a carefully kept account of the substances used for the bill of fare the following "food equivalents" have been reduced, showing that each diner receives, of:

Albuminoids.....	0 63 oz.
Fat.....	0 44 oz.
Carbohydrates.....	3 17 oz.
Mineral matters.....	0 09 oz.
Physiologists lay down the standard diet for ordinary labor pretty much as follows:	
Albuminoids.....	4 2 oz.
Fat.....	1 6 oz.
Carbohydrates.....	18 7 oz.
Mineral matters.....	1 0 oz.

It appears, therefore, that it would require about six of the sixpenny dinners to support a man during a day's hard labor.—*Medical Times and Gazette*, May 24, 1884, p. 712.

to sleep when hypnotics would fail of their purpose.\* Food before rising is an equally important expedient. It supplies strength for bathing and dressing, laborious and wearisome tasks for the underfed, and is a better morning "pick-me-up" than any hackneyed "tonic."

That the particular food is alleged to be unpalatable, or the hour at which it is to be taken inconvenient, is of no importance. Indeed, it sometimes lends a helping hand to have each mouthful considered the equivalent of a dose of medicine. A tablespoonful of cod liver oil is often taken regularly and amiably when even the smallest quantity of some inviting delicacy will not be swallowed. It is a matter of observation, says Mr. Francis Galton, that "well-washed and combed domestic pets grow dull. They miss the stimulus of fleas." The energy required to dispose of that which is disagreeable is often a discipline of great service to certain classes of persons. Their faculties need to be whipped and spurred to prevent them from perishing by disuse, and the degree of vigor capable of being generated is often proportionate to the amount of coercion to which they are subjected.

The rugged way, however, may be smoothed by various procedures, and need not be made unnecessarily hard to travel. It is helped by selecting food containing the most nourishment and the least bulk, and which is easiest to swallow after a minimum of mastication, or without any. The culinary art facilitates the ingestion as well as the digestion of meats, which, without its cajolery, might be tough and uninviting. Skillful feeding by a nurse who recognizes the art which may be exhibited in coaxing food into the stomach is often of advantage. Food thus administered must be introduced in large mouthfuls. Every gourmet knows how necessary this is for the satisfaction of the palate, and the correctness of the fact is substantiated by reason and by analogy. Well-shaped, wisely-seasoned, large morsels make a relishing and appetizing mouthful, inviting repetition. In divided bits they quickly satiate or excite repugnance. By this epicurean method the stomach is rapidly and persuasively charged with a sufficient supply of nourishment, as it never can be by the feeble pickings of an apathetic eater. *L'appetit vient en mangeant* is a paradoxical adage constantly verified. Not only mere disinclination to eat is often successfully overcome by persistent feeding, but a liking for and dependence upon full and hearty meals is established and, what is more, retained.

In cases where food is urgently called for, its artificial introduction is an easy and beneficial maneuver. It does not require a stomach tube, and has but little resemblance to the procedure resorted to with the insane. It may be practiced with insignificant discomfort by means of a soft rubber catheter, not exceeding a No. 12 in size, fitted to a small glass tunnel, into which the nutriment is poured, or it may be sent through the tube by a Davidson's syringe. The catheter need enter but a short distance into the esophagus. If no resistance be offered, the operation can be performed by almost any one, even by the patient himself. Milk, cream, broth, eggs and homogeneous liquids are thus readily deposited, and to the desired extent, in the stomachs of those disinclined to eat.

The number of females, especially those who "do their own work," whose food consists almost wholly of bread and tea is very large. How inadequately they are nourished is shown by the statement that, in order to get the required amount of aliment, persons who eat nothing else must consume about four pounds of bread. As this is so much more than any one can dispose of with comfort, the practice of eating butter with bread is almost universal. This not only meets the necessity for a heat-producing, non-nitrogenous food, but the unattractive character of dry bread as an eatable is compensated for by the relish of a savory addition. In proportion as the use of butter is increased, the requisite quantity of bread may be decreased. To eat "more butter than bread" should not therefore be the reproach to growing children which it is often made, and the large amount of the former which may be profitably disposed of by the underfed, without "disturbing their stomachs," is not surprising if the process by which oleaginous substances are taken into the system is recalled. "Fat, butter, and oily matter in general require no digestion; the emulsion into which they are mechanically converted, chiefly by the pancreatic and duodenal secretions, passes (almost directly) into the general circulation of the blood." For reasons similar to those which make cream and butter such useful articles of diet, and because the habitual food of insufficient eaters is so lacking in fatty matter, cod liver oil has acquired its well-deserved place among therapeutic and alimentary agents.

The tendency of those whose appetite is deficient to lay great stress upon their readiness to take food which does not require mastication makes them willing consumers of soup. And yet of all articles entering into the common dietary soups are perhaps the most deceptive, and certainly the most important to discountenance with the underfed. They fill up the stomach at the expense of solid, "staying" nourishment, and contain so little in the way of sustenance that they are therapeutically almost worthless. As a rule they are but some form of meat tea, and are now known to have a food value not unlike that which urine would possess, were it drank, and which they resemble chemically. "They may have on the system a stimulant action somewhat analogous to theine. They may render more prompt and efficacious the assimilation of any wholesome food with which they may be associated, and they may even give so effective a flip to an exhausted system as to enable it to dispense for a time with real food, but it is clear that they must not be looked to for direct nutrition." The established use of *bouillon* at luncheon and "Germans," and of a "clear soup" at the commencement of dinner, is thus accounted for; and it is only in a sense such as has just been indicated that the Crimean saying, "Soup makes a soldier," has any justification in fact.

Broths, however, that is, soups which contain large quantities of solid matter, disintegrated meat,† vege-

tables, macaroni, vermicelli, *pate d'Italie*, rice, barley, sago, tapioca, etc., are often, and in proportion to the consistency thus given, excellent alimentations. They are palatable and easily consumed in considerable quantities at a time. *Soupe a la Reine* *puree de gibier*, various vegetable *purees*, chowder of fish, *bisques* of oyster, clam, lobster, are illustrations of the perfection of this kind of cookery. That they may be what is sometimes called "rich" is no objection. The digestive powers of the underfed are usually good, though the owners of them may not think so. They are apt to be active and ravenous even if the appetite is not.

Notwithstanding its capacity to digest, there is, invariably, something repulsive to an insensible stomach in what are conventionally called "roasted joints." This antipathy, together with considerations of convenience as regards the size of portions to be cooked, makes it almost imperative, for protesting but frequent eaters, that meats should be either broiled or stewed; and steaks of various kinds, chops, cutlets, chicken, game, some kinds of fish, and shell fish, become, therefore, the only really available resources of the caterer for an ill-ordered appetite. And yet no more difficult undertaking can be given non-hungry patients than that of eating beefsteak. Apart from its somewhat uncertain quality nothing requires more mastication, and the class named always declare that there is no item of food of which they are already more "tired." Any other variety of meat, mutton, veal, venison, etc., cooked in the form of steak, is more readily eaten. The short, compact fiber of mutton chops, especially those from the loin, makes them less likely than beefsteak to be badly cooked, and far easier to be consumed. Well selected, carefully cut lamb chops, in their proper season, are a delicacy of the highest order, and rarely fail to be appreciated by the most benumbed eater.

Meats stewed, or semi-stewed, and then partially browned in the oven (braised, as it is called in the language of cookery), are attractive and submissive preparations, and this method of cooking is an excellent one for purveying small portions of animal food. In the various forms and denominations of stewing and braising, the *cordon bleu* finds scope for the highest aspirations of culinary art.\* They impart an appetizing flavor to viands cooked to extreme tenderness, the perfection of these methods being found in their application to sweetbread, a costly luxury, but an article which, by its slight demand for mastication and its nutritious qualities, is peculiarly adapted to the requirements of an invalid eater. Others of the viscera, besides the pancreas and the thymus gland, namely, the brains, the liver, the kidneys, the testicles of lambs, successfully lend themselves to this process of cookery, and, like calves' heads, pigs' feet, and sheep's tongues, are converted into delicate and easily assimilated nutriment for those who are ignorant of, or can overcome, the associations which they suggest.

Of various mechanical processes available for rendering food easily eaten, preparatory mincing offers great advantages, and is particularly applicable to chicken and veal. A common and attractive method of serving both in the form of minced meat is that of *croquettes*. I am at a loss to know why veal is so often proscribed rather than prescribed. Its chief defect is in being a lean meat, containing more water and less fat than mutton or beef, and consequently of subordinate nutritious value. It is, however, the standard meat of France, as beef is of England, and properly chosen veal, from large calves, is open to no dietetic objection which I am aware of except the difficulty of cooking it well. It is not less digestible than other young meats, and if occasionally "poisonous," it becomes so from decomposition, which, in the season of its abundance, more readily takes place from keeping, or changes in the weather, than is the case with meats of maturer growth. But this, like poisoning by partridges which have been too long kept in winter time, is an inexcusable accident.

In spite of the somewhat flippant assertion of a justly distinguished medical writer that "there is a growing incapacity to digest fat which is truly alarming," I do not hesitate to assert that of all the modes in which minced meat may be presented the calumination and much libeled sausage is, in winter time, one of the most useful and successful articles for frequent feeding. Lean and fat meats, more digestible together than separately, are indiscriminately mixed in the compact and appetizing form of this ubiquitous and popular comestible, the sole secret of whose easy digestion is that it should not be eaten except when it has become thoroughly cold after cooking. Bread and butter can be tolerated with complete immunity when hot buttered toast would provoke exasperating dyspepsia, and it is exactly thus that sausage cold stands in relation to that which is served hot. Presenting the albuminates and fat in an economical, savory form, easily obtained and made ready for consumption, sausage, in some countries, might almost be said to have become a national food, and it offers to the fastidious or indifferent eater an article of diet from which great benefit may be derived. A trial of this stigmatized edible will be followed by a ready recognition of its alimentary value in the class of cases under consideration.

As has been remarked already, food to be taken outside the conventional meal hours must be of a kind easily obtained anywhere, readily "kept in the house," and which does not demand preparation or delay. Few persons can command the services of a "professed cook," or of a good "plain" cook, or have either at their disposal every two hours in the day. The practical articles of diet which meet these restricted requirements of convenience are few, and of these the chief in importance are eggs, milk, cream, butter, and bread.

Raw albumen is one of the most digestible of foods; coagulated, it is comparatively indigestible.‡ Eggs to be easily digested must be eaten uncooked, since albumen under prolonged heat acquires progressive degrees of toughness.§ When cooked, buttered, salted, and peppered they are soon tired of as articles of food, and alleged to be "bilious." Cooking, moreover, involves waiting and preparation. An uncooked egg is

always ready and at hand, is clean to be kept anywhere, and scarcely needs to be broken into a glass.

With a little knack it may be swallowed direct from the shell, as most persons know if in childhood they have had access to country barns. A raw egg weighs from two to two and a quarter ounces, and is said to contain about the same flesh-forming and heat-giving material as an equal amount of butcher's meat.\* It offers in perfection the quickest and neatest mode of taking a large equivalent of substantial and nutritious food at a swallow. Every bar-room realizes this, and supplies its counter with a bowl of eggs. The steady drinker, who has eaten nothing for breakfast and has no appetite, but who knows the injurious effects of a drink on an empty stomach, can crack an egg, quickly dispose of it, and justify himself for an early dram. Even "soda shops" appreciate their value, and dispense them with lemonades and phosphates. Beaten-up eggs are the certain provocateurs of dyspepsia. When subjected to this process with the infinite painstaking of an attentive friend or nurse, an inviting draught of creamy froth is brought to the unfortunate recipient—a tumblerful of air, which has been introduced in the largest possible amount to a given quantity of egg, milk, wine, sugar and nutmeg—than which nothing could be better devised to promote indigestion, abdominal eructations, and the most uncomfortable flatulence or acidity. Every beer drinker has the good sense to blow off the "head" of his mug of beer or to wait patiently for the froth to subside, before he imbibes the draught; and if crotchety persons will not learn the trick of swallowing an egg whole, they can compromise the difficulty by slowly stirring the white and the yolk, which may be thus mixed together, and made to seem a less revolting dose without the incorporation of air by beating. Taken as a medicine, and looked upon as such, eggs are at least equally palatable with cod liver oil, for which they offer an equivalent substitute, adapted to winter or summer, as the latter hardly is, are far more readily digested. There is no limit to the number which may be taken with advantage continuously and for months at a time. Eighteen eggs are required to furnish the flesh-forming materials and other nutrients sufficient for the various needs of an adult man in one day. No more striking illustration of their concentrated food value, or a better proof of its general appreciation, can be given than the statement that during the first quarter of 1876, in Great Britain, the consumption of eggs reached the enormous number of seventeen and a quarter millions.† Fifteen millions were imported into the United States from Europe in the year 1883. It is but fair, however, to remember that a vast number of eggs are used in the arts, especially photography, and in manufacturing processes.

Milk and cream are convenient and therefore important and desirable articles of food. It is a common assertion of patients that milk "always disagrees with them"—that they have "never been able to take it." This statement, which, as a rule, may safely be attributed to mere prejudice, is also in some cases a true one, simply for the reason that the milk is drunk too rapidly, or because it is not rich enough, an easy remedy being to take the given quantity more slowly, or to increase by addition the amount of cream which the milk naturally possesses, the trouble being due, in the first instance, to the fact that a large and solid cheese curd is suddenly formed in the stomach by the rapidity with which the milk is deposited in that organ, and in the second, to the hardness of the casein derived from milk with an insufficient percentage of cream, which is always inconstant in amount (varying between 10 and 15 per cent.) or in composition, the water alone ranging from 45 to 65 per cent.‡ Milk is often too poor, but never too rich, for purposes of enforced nutrition, and the fact is incontrovertible that it is the model food for digestibility.§ By adding cream to milk the amount of fat is increased and the curd is softened; and its digestion can be still further facilitated by the disintegration of its coagula, accomplished by crumbling into bread, cracker, etc., or by the addition of a small amount of cooked meal or flour.

By this latter means cold milk is made warm, which gives it an increased efficacy. This end may also be attained and the distastefulness of warm milk removed by flavoring it with the preparations of cocoa, weak coffee, or some of the inert substitutes for the latter sold by grocers, the best of which, it has seemed to me, is known as "New Era coffee," consisting simply of roasted and ground wheat. But, as hot milk demands a certain amount of trouble, cold milk alone, or with bread broken into it, is, after all, the only practical resource so far as its use for frequent nutriment is concerned; and two quarts of milk, or three pints of milk and one pint of cream, are not more than the minimum quantity desirable for ingestion in twenty-four hours. Clear cream may be administered in doses of a wine-glassful after each meal, as any other medicine might be, and a great deal can be disposed of by eating it liberally added to cooked fruit and various dessert dishes.

*Blanc mange*, Italian cream, and the various forms in which many delicate farinaceous articles are cooked, may thus be made more eatable through the zest given them by this accompaniment. There is a great difference in the palatableness as well as digestibility of cream which is obtained from milk by centrifugal force, as is largely done for the market, and that which is skimmed after "setting." This distinction should be borne in mind in prescribing cream which is to be taken uncooked. The last-named product is by far the most desirable article.

Very few patients, especially women, drink a sufficiency of water to maintain their health or an adequate nutrition. Water is an important constituent of food, is indeed the carrier of food into and through the system, and forms more than two-thirds of the whole body. Neglect to keep up the supply of water leads to

\* Church, p. 147.

† Church, p. 148.

‡ Church, p. 136.

§ The analysis of "market" milk sold in Philadelphia and New York is as follows:

Water	87.7	per cent.
Total solids	12.3	"
Total solids, not fat	8.28	"
Fat	3.75	"
Milk sugar	4.62	"
Albuminoids	0.42	"
Ash	0.04	"

—A. E. Leeds, Medical News, July 21, 1902.

\* It should be borne in mind that a full bladder is a frequent cause of early morning wakefulness. Rising and passing water will often send restless sleepers back to bed for a refreshing nap, which without relief from this source of reflex irritation would not have occurred.

† The meat from which soup is made, allowed to become cold, should be pounded to a paste in a mortar, and then returned to the soup. Veal, pigeon, and rabbit are especially adapted to this procedure. "French" cooks prefer to make "chicken broth" from rabbit.

\* The details of braising and other refined culinary processes are feelingly particularized by Sir Henry Thompson in "Food and Feeding," third edition, London, 1884.

† Twining, p. 184.

‡ Eggs should not be cooked by boiling, but by placing them in hot water, and allowing them to remain there from seven to ten minutes.

a diminution in the quantity of blood, and lessens the body's strength.\* When it is remembered that there are daily eliminated from 18 to 32 ounces of water from the skin by perspiration, 11 ounces from the lungs, and 50 ounces from the kidneys, it is easy to see that the amount consumed by many persons falls short of the demand, and that their bodies must be insufficiently supplied with the requisite degree of moisture; some 60 ounces of water alone, and in tea, coffee, beer, etc., being required for a daily supply over and above that which is contained in the solid food of a full ration to make good the average regular waste.† The constipation which is so common in ill-nourished persons is largely due to a want of liquid in the intestinal canal. This, therefore, will be ameliorated by the free use of water, as is also the constipating tendency of milk, which is sometimes complained of, the curds being liquefied and reduced in size, and thereby made more readily digestible. Its effect on hardened fecal masses or accumulated mucus in the intestines is equally obvious, and explains in part the intention as well as the success of the hot-water craze at present so popular.‡

The underfed are benefited, and the process of feeding is helped, by alcohol. But the amount of alcohol which such persons may take as a food adjunct with advantage is very small. The cumulative effects of a medicinal dose at stated intervals are of greater utility than the more instant result of a larger allowance swallowed in a single drink. A measure of alcohol which produces an effect quickly, that is, which flushes the face, or exhilarates, as a sherry-glass of wine does with most females, for instance, is a toxic dose, and will be followed by reaction. It is a quantity short of this which is allowable. A teaspoonful, or at most a dessertspoonful, three or four times a day, is usually as much as can be borne without such sequelae as are above alluded to.

Spirits serve their purpose better than wine, for the reason that the relative quantity of alcohol administered is more measurable. Wines vary in strength; spirits are comparatively uniform. Tinctures even, or elixirs, may be given when spirits are objected to either on principle or from prejudice. In any case there should be a large dilution with water, as a more gradually stimulating effect is thus produced. Alcoholic medicines ought never to be taken on an empty stomach.§

The subject of bathing, incidentally alluded to, leads me to call attention to the fact that cold baths chill down the feeble circulation of the badly nourished, and provoke a physical torpor which is obstructive to the processes of nutrition. They drive the blood from the surface of the body in upon vascular organs, whose circulation is already sluggish from general weakness. They thus produce discomforts which aggravate existing languor, and enhance the feeling that food and drink ought not to and therefore cannot be taken. A bath described as one "from which the chill has been taken" is too cold for subjects under medical advice who are in need of extra feeding.

Great pains should be taken to discountenance everything which reduces the bodily heat, and employments or amusements which in any sense tax the strength ought to be abandoned when a forced diet is attempted. Even ordinary exercise is often objectionable, and its complete discontinuance sometimes so important that confinement to bed is a necessity. Those who raise animals are practically made aware that a restless disposition is fatal to successful growth in vigor and flesh. The truthfulness of this observation is equally apparent with human beings who need "building up" in the literal sense of these remarks.

More fattening is not the object of full feeding, but it is to a certain extent its necessary accompaniment. The motive of the measure, as has already been stated, is to add to the quantity and quality of the blood, and it is hardly possible for an individual to grow fat without a decided increase in the volume of his blood. Weighing at stated intervals is therefore an important procedure, and there is no other way to make sure that the subjects of treatment are sufficiently well fed to gain blood. Persons who put on fat rarely fail to improve in color; their comfort is enhanced; warmth of body is gained, in itself no slight improvement; the pulse becomes fuller; the cheeks grow redder; the spirits are raised; the general mien becomes brighter; and these phenomena are explainable only by admitting that there has been an accession to their stock of blood. The scales thus become a thermometer of improving health and strength, by the aid of which the physician measures the progressive results of his regimen. Like the "pass book" used at banks, they reveal in a ready and serviceable way the healthful standing of an individual, the relation of his resources to the wear and tear which he is continually drawing, and whether his account is nearly or quite overdrawn, or superfluously pléthoric. They ought not to be put into requisition too frequently, and only when there is reason to think that an encouraging increase of weight has taken place. This should manifest itself soon after systematic feeding has begun, and continue at the rate of two pounds a week, and not less than one pound, so long as improvement seems desirable, or until a weight has been reached the minimum of which shall be equivalent to two pounds for each inch of stature.

Experience and observation have universally confirmed the expediency of a heartier and more systematized diet than recently prevailed. Its utilitarian advantages are publicly recognized. Within twenty years the rations of armies, of institutions, charitable, penal,

and medical, have been liberally increased. Family habits in regard to eating, since the flush times of the civil war, have greatly changed, and the large allowance of food requisite for the maintenance of a sound health can scarcely be exaggerated in any statement of its details. In the application of this accepted dogma to special and personal cases there is much, however, still left to be desired.

I cannot better conclude this paper than by a paraphrase of Mr. Clifford Allbutt's words in his recent Gulstonian lecture,\* wherein he observes, although not precisely in the language which follows, that: Under the benign and self-controlling influences of an amended nutrition, the domestic atmosphere changes. Sore throats and trivial indispositions, which once raised the frequent suggestion of a conflict with school, or a dinner, or an evening party, no longer present themselves as subjects for anxiety. Headaches and vague, transitory pains disappear. Ill temper, fretfulness, the fidgets, crying spells, shrewishness, sleeplessness, listlessness, vanish away, and the complaint of being "good for nothing" ceases to be made. By the building up of digestive resources a reserve of strength, which never before existed, is created, or a wasted one is restored, not merely for use on great occasions, but, by its wisely managed expenditure, to serve permanently for the silent work and equable running of vital machinery. Convince underfed invalids that no further defalcation of diet or new combination of drugs is needed; that instead of waving dishes aside, like the physicians of Sancho Panza, they should be indulged in liberally, and they will find health within their reach; and by careful advances and the frequent repetition of small and highly nutritious meals realize that they can steadily eat their way upward to a regenerated and tranquilized condition of body and mind.

#### HOW PLANTS ARE FERTILIZED.

BOYLSTON HALL, in Cambridge, was lately crowded to its fullest capacity by an audience composed of as many Cambridge people as students in the college. At half-past seven o'clock the lecturer, Prof. Trelease, of St. Louis, was introduced by Prof. Shaler. His remarks were illustrated by projections on the sheet behind him.

The lecturer began by illustrating the interior mechanism of a flower. Every flower, he said, is made up of organs called essential and non-essential. The essential organs are the stamens and pistils, which are the generative organs, male or female, of the flower. The non-essential organs are the calyx and corolla. The stamens produce pollen, which, placed on the pistil, excites the secretions of the stigma and style of the pistil, and these make their way down a channel to one of the ovules or undeveloped seeds within the ovary. Protoplasm takes place, making fertilization complete. This, the lecturer declared, was the subject he was to talk about.

He divided the fertilization of flowers into four classes: Those which fertilize themselves and those which are fertilized by the means of wind, water, and animals. The first class contains very few flowers. For instance, our common violet becomes fertilized while yet in the bud. The stamens and pistils, touching already, transfer the pollen even before the flower is open. The second class is very much larger. The most common example of it is the Indian corn, the so-called silk corresponding to the pistil of the flower and the tassel to the stamen. The wind shaking the tassel carries the pollen by cross fertilization to other stalks. The wind often carries the pollen a third or a half of a mile, so that farmers are often obliged to build hedges to separate different species of corn, as these are found to prevent the spread of the pollen. One of the commonest causes of complaint against the English sparrows is that they feed upon the pollen of the corn and prevent its fertilization. Trees of this class, as the poplar, the maple, and the pine, generally produce their flowers before their leaves, in order not to obstruct the passage of the pollen. The third class, consisting of water plants, such as the lily, eel grass, and others, are fertilized in a curious manner. The staminate and pistillate flowers are born near the base of the plant under water. The latter rise on long stems, come to the surface, and catch the former, which break off and float to the top. Coiled stems draw the flower under the water again to fructify. At this point the lecturer threw upon the screen the face of Erasmus Darwin, to whom, he said, we owe so much in this branch of the science.

Prof. Trelease then went on to speak of the flowers which were fertilized by the aid of animals—snails, insects, and birds. These animals do an immense service in the fertilization of plants, but they do it unconsciously. Nor do they work without pay. They are always attracted to the flower by the food, warmth, or shelter in it. This food is advertised by color and odor. Delpino was the first to discover the part played by snails in this fertilization. When the snail enters the flower, the slime with which he is enveloped catches the pollen from the stamen, and either carries it down to the pistil of the same flower or of another. The gnats are attracted by small, tubular flowers, like Dutchman's pipe, where they are imprisoned for a time until they have performed the work of fructification by pushing the pollen from the stamen upon the pistil. Bees and balancing flies enter flowers in search of nectar, and carry into the pistils the pollen which they brushed from the stamen on to their back. Moths receive pollen on their tongue, or even in their eyes. They alone are fitted to fertilize some of the longer backed flowers. Some plants, like the yucca or Spanish bayonet, are fertilized by insects who seek to leave their eggs in the ovary of the flower. The sores, honey birds, and humming birds are the only birds which fertilize flowers. Owing to their strength of wing, stability of poise, and length of bill, they are able to extract the honey from the deepest flower. At the same time they shake down on the pistil beneath the pollen at the entrance of the flower.

Prof. Trelease finished the lecture by speaking of Sprengel and Prof. Charles Darwin, whose portrait was also cast upon the screen. To Prof. Darwin's theories and researches he paid a high tribute. Through his works, and in the study itself, Christian thinkers who believed in a Creator could see his hand in the functions and dispensation of the minutest organ

of these pretty adornments to earth. On the other hand, these of the ultra-German theorists who think there is no other God than carbon can marvel at the unconscious agency of insects and birds in the fertilization of these plants, when impelled by the natural desire of food alone.—*Boston Advertiser*.

#### PYRIDINE.

PYRIDINE has been known to chemists since 1856, when it was discovered in London by Greville Williams. It belongs to a group of compounds (alkaloids) known as the pyridine bases, which are formed in the dry distillation of nitrogenous compounds, such as bones, wool, alkaloids, etc. Nicotine, the active principle of tobacco, is one of them, and pyridine is largely present also in the products of the distillation of tobacco. Pyridine is a colorless fluid with a peculiar odor; it is soluble in water, and boils at about 116° C.; it rapidly absorbs moisture, and has been recently applied as a remedy for asthma.

A young German medical student, H. Rosenbluck, who is now studying in Paris, has made some observations on the action of pyridine in the wards under the care of Professor Germain See. He has tried the effects of this new product in various forms of asthma, and tells us that the nervous and emphysematous forms were rapidly relieved by it, nausea and giddiness being noticed only once.

The presence of bronchial catarrh, he says, is no contra-indication to the treatment, which was carried out by allowing four or five grammes of the liquid to evaporate from a flat dish in a small room, the patients being exposed to the vapor for one hour and a half three times a day.

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\* The characteristic thirst which attends great and sudden losses of blood is a symptom of interest in this connection.

Some valuable comments on the therapeutic uses of water, by Mr. Lauder Brunton, may be found in the *Practitioner*, May, 1884.

† Church, p. 51.

‡ There was perhaps more common sense than Martin Chuzzlewit supposed in the American habit, prevalent when people lived more frugally, and went to bed with empty stomachs often than nowadays, which he noticed in his fellow boarders at Mrs. Fawkins', "who, after taking long pulls from a great white water jug upon the sideboard, and lingering with a kind of hideous fascination near the brass spittoons, lounged heavily to bed." Water drinking was indulged in thirty years ago more than at present, and in the half-starved existence which bred the lank and conventional type of American in those days, I cannot but believe that the comfort and well-being of the then living community were greatly promoted.

§ There is much pragmatical talk about "pure liquors," and the difficulty of obtaining them. It may be questioned whether alcohol and water, except for an educated and fastidious palate, is not as wholesome for medical uses as any high cost wine or spirit. Noxious impurities, when they exist, are usually, owing to imperfect distillation, or lack of age, rather than to deliberate "doctoring."

